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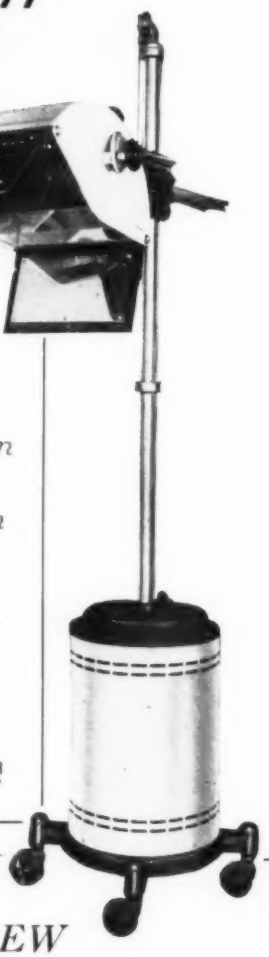

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PHYSICAL THERAPY IN FRACTURES ABOUT ELBOW JOINT *

MILAND E. KNAPP, M.D.

MINNEAPOLIS

Injuries in the region of the elbow joints are of particular interest because of the frequency of resulting permanent deformity and disability and slow return to normal function often observed in apparently trivial fractures. Even in children permanent deformity is not uncommon, while in adults disability of some degree is almost the rule. Minimal fractures and those without displacement may be embarrassingly obstinate in recovery, and a severe fracture constitutes a major problem so far as restoration of normal function is concerned. A partial explanation may be sought in the anatomic complexity of this joint.

Anatomy

The elbow is a triple joint consisting of the humero-ulnar, the humero-radial, and the proximal radio-ulnar articulations. The articular surfaces fit very snugly into each other and are firmly held by powerful ligaments without allowing any side motion. The true hinge movement is guided and limited accurately by the configuration of the bones. This movement is normally slightly oblique from lateral to medial on moving the elbow from a position of complete extension to one of complete flexion. This explains the presence of the carrying angle in extension and its reversal in flexion. The extremes of motion are limited by the depth of the olecranon fossa posteriorly and the coronoid fossa anteriorly. Any interference with these fossae will cause limitation of the extremes of flexion or extension.

The humero-ulnar and humero-radial joints are concerned mainly with flexion and extension. The humero-radial joint also allows rotation of the head of the radius upon its articular surface, the capitellum.

The radio-ulnar joint permits rotation of the forearm through a range of approximately 180 degrees. It is firmly restrained by the strong annular ligament. However, its motion may be limited by thickening or tightening of the oblique cord or the interosseous membrane in the forearm as well as by adhesions or injury to the annular ligament itself or the radial head or neck.

The important consideration from a functional point of view is that all these motions are rigidly controlled by the contour of the joint surfaces and by firm ligaments so that no allowance is made for poor reductions. All the structures are firm so that minimal adhesions result in maximal disabilities.

Cases

The following opinions are based upon the observation and analysis of 180 cases of fracture and dislocation of the elbow joint treated at the Minneapolis General Hospital and followed in the out-patient department between January 1, 1936, and July 1, 1940.

These cases are classified as follows: Supracondylar fracture of the humerus, 63; fracture of the head or neck of the radius, 41; fracture of the olecranon process of the ulna, 33; dislocation of the elbow with or without

* Read at the Nineteenth Annual Session of the American Congress of Physical Therapy, Cleveland, Ohio, September 3, 1940.

associated minor fractures, 18; fractures of the capitellum of the humerus, 17; separation of the epiphysis of the medial epicondyle, 5; fracture of the coronoid process of the ulna without dislocation, 2; and separation of the epiphysis for the lateral epicondyle, 1 case.

These patients were followed by actual measurement of joint function whenever possible until the injured elbow had recovered to within 5 degrees of each measurement of the normal elbow or until the range of motion had remained stationary for one year. Of course, a fair number of these patients were lost during the course of the follow-up, but many of them were again contacted after two or three years for a final evaluation of the functional end-result. This was especially true among those who did not receive physical therapy since many of them were advised to have treatment but did not return for it, and a number were released to their private physicians, whereupon the follow-up ceased. The average age is given in the accompanying table.

TABLE 1. — *Average Age of Fracture Patients.*

Type of Fracture	No. of Cases	Average Age in Years	Under 10	Over 20
Supracondylar	63	13.4	40	7
Head of Radius	41	36.1	2	32
Olecranon	33	28.9	4	19
Dislocation	18	27.6	4	9
Capitellum	17	19.5	9	5
Separation of epiphyses of epicondyles	6	11.3	2	0
Coronoid	2	28.5	0	1

One hundred five, or 58.3 per cent of these cases received treatment in the physical therapy department at some time during the course of their recovery. This is ample evidence of the fear entertained by the surgical staff of the probability of poor results without treatment and their confidence in the usefulness of physical measures, since the proportion of all fractures receiving them is 27.5 per cent. Thus over twice as many fractures of the elbow joint received physical therapy as did fractures in general.

Those who did not receive treatment were ordinarily in the younger age groups with minor fractures or were so old as to be unmanageable, or did not return for various reasons. Table 2 shows the number and percentage of cases of each type given physical therapy, the average number of treatments and the range of treatment.

TABLE 2. — *Types of Fractures Given Physical Therapy.*

Type of Fracture	No. of Cases	No. of Cases Given P. T.	%	Av. No. of Trts.	Least No. of Trts.	Greatest No. of Trts.
Entire series	180	105	58.3	.....	....	....
Supracondylar	63	34	54.	14.8	1	48
Head of Radius	41	29	70.7	11.5	1	64
Olecranon	33	15	45.4	26.1	8	58
Dislocation	18	10	55.5	22.7	2	64
Capitellum	17	14	82.3	19.2	1	63
Separation of epiphyses of epicondyles	6	2	33.3	10.5	6	15
Coronoid	2	1	50.	6.	6	6

Causes of Limitation of Motion

Physical therapy in fractures about the elbow is primarily concerned with the maintenance and restoration of motion in this joint. The principal causes of limitation of motion may be listed as follows:

1. *Reduction.* — Accurate reduction of the fracture is especially important about the elbow joint because of the compact character of the opposing surfaces and the absence of allowance for anatomic variations. Rotatory displacements are particularly to be detected and corrected since disturbances in the carrying angle may result from minor rotations especially of the capitellum. Minor residual displacement may result in major residual deformity. Posterior displacement of the distal fragment in supracondylar fracture is prone to cause limitation of flexion which is only corrected by reformation of the bone if the patient is young. Fortunately the majority of these patients are very young. Frequently surprisingly good functional results may be obtained with the passage of time in rather poor anatomic reductions if there are no rotary displacements and the patient is young.

2. *Callus Formation.* — Only very rarely is non-union or fibrous union a factor in the function of these cases, and then usually only in inadequately reduced fractures of the olecranon. Excessive or even moderate callus formation in the wrong place, the olecranon fossa for instance, may limit motion by mechanical interference. This especially limits extension. It has been stated that early motion favors the formation of excessive callus. This has not been my experience. However, extensive soft tissue injuries by repeated attempts at reduction by manipulation or by open operation may cause excessive new bone formation. It may take as long as six months for the callus to absorb enough to allow normal extension even if the reduction is perfect. No treatment we have tried will appreciably shorten this period.

3. *Myositis Ossificans.* — It has been stated that early motion predisposes to the condition known as myositis ossificans. This has definitely not been observed in this series. There have been only two actual cases of myositis ossificans in this group, both in the anterior part of the elbow joint, a boy 7 and a girl 11 years old, who had open reduction of fractures of the capitellum. This condition was noticed when the first x-ray was taken after removal of the cast. In the first patient no motion had been attempted and the cast was immediately reapplied. In the second patient whirlpool baths had been given for two weeks before the x-ray was taken. Three other patients, aged 41, 57, and 59, showed small calcifications on late x-rays, which probably represent small calcified hematomas that did not interfere with function.

Treatment of the cases of myositis ossificans consisted of immobilization in plaster with daily long continued short wave diathermy on the theory that increased arterial circulation would cause absorption of calcium as it does in other locations. Both improved greatly in function, but by x-ray the calcifications were not materially changed.

4. *Adhesions.* — Marked soft tissue damage as evidenced by swelling, discoloration and blistering of the skin, is a frequent cause of permanent disability. The edema and hemorrhage become organized with the formation of fibrous adhesions. If immobilization is prolonged in the face of these findings fibrosis ensues, which may be impossible to overcome. Prevention and relief of swelling as quickly as possible is of prime importance as in all fractures. In my opinion immobilization beyond four weeks may be continued only if no other course is feasible.

5. *Forced Motion.* — Forcible manipulation with or without anesthesia is virtually contraindicated in nearly every instance. Increase of trauma and hemorrhage and decrease of function is the almost invariable result. We have learned to allow active motion only within the limits of pain. This is repeated as frequently as possible since constant repetition of purposeful movement seems to increase function most rapidly. Some of our early fail-

ures, I believe, were due to attempts to force motion in the elbow joint.

The only patient who has received manipulation under anesthesia in the last several years, was a boy aged 12 with a high supracondylar fracture of the humerus which was very hard to reduce. He was immobilized in a shoulder spica for 85 days because the resident surgeon was afraid the fracture would slip. After almost a month of the usual treatment the extremes of motion were extension, 65, and flexion, 40, a range of only 25 degrees. A diagnosis of inclusion of the flexor tendons in callus was made. He was referred to the hospital for freeing of the tendons by open operation. Instead, a manipulation under anesthesia was performed. Physical therapy was then continued for five more months at which time the patient could extend the elbow to 150 and flex to 55 degrees.

Treatment

With these considerations in mind we have formulated the following principles for physical therapy in the management of elbow joint fractures and dislocations.

1. Treatment should be started as early as is consistent with maintenance of the reduction. Usually at the end of ten days to two weeks there is sufficient soft callus formation, so that guarded active motion is feasible. More than four weeks of constant immobilization should be regarded with trepidation. If open reduction and internal fixation have been used and if the internal fixation is adequate as in fractures of the olecranon or head of the radius, no immobilization should be necessary. Treatment may then be started as soon as the wound has healed.

2. Absolutely no pain should be caused by the treatment at any time. We have found the whirlpool bath most satisfactory for early treatment. With this measure we obtain relaxation of muscles and relief of pain, and at the same time active motion may be performed by the patient with reduced resistance and without fear of displacing fragments.

3. Swelling should be promptly treated by elevation, release of tight bandages, and active motion of the fingers. At times removal of splints followed by superficial stroking massage may be necessary. Hospitalization should be insisted upon if facilities at home are inadequate or if the swelling does not subside quickly.

4. Exercises should be entirely active, be begun very mildly and gradually increased in strength and duration as the patient improves. I prefer exercise on the pulley weights and shoulder wheel for the later stages in difficult cases. The pulley weight exercise consists in motion in all directions—flexion, extension, and rotation of elbow and shoulder—but especially a punching motion with the patient facing away from the weights and striking out with the injured hand. This produces active extension of the elbow against resistance with reflex relaxation of the flexors and thus allows the greatest possible extension and the quickest return of this motion.

I do not like the use of a weighted lead cuff, or the carrying of pails of sand, or even hanging from a pole for the following reasons: These motions all tend to cause contraction of the flexors in order to hold the weight of the device or of the body. Especially is this true if the elbow is slightly painful. In this way exercise of the flexors is accomplished, instead of use of the extensors, which is the original purpose of the treatment. It has been stated that if a lead cuff is used and kept on continually the flexors will tire, and extension will be accomplished. In order that this can take place, an extremely heavy weight is required, and the patient's good arm must be tied to prevent him from assisting his tired muscles with the unin-

jured hand. Such a weight effectively hinders active use of the injured arm and thus definitely prevents quick return of function. Usually all it accomplishes is to change the arc of motion from a range from 70 to 120, for instance, to the range from 100 to 150 degrees, a much less useful arc of motion, but it seldom increases the size of the arc. Occasionally a rather light lead cuff (1 to 3 pounds) is useful if flexion is normal and free, but extension is slightly limited.

5. Frequent x-ray rechecks should be made for four reasons. First, to be sure that position is not lost; second, to follow the progress of union; third, to determine whether limitation of function is due to excess callus or normal callus in the olecranon fossa; fourth, to reveal the presence of myositis ossificans or calcifying hematoma.

6. There is nothing gained by continuing treatment indefinitely. If improvement stops and motion remains stationary for a period of four weeks, careful examination and diagnosis of the cause should be made. If no cause can be found, treatment should be discontinued and the patient followed-up solely by measurement. Sometimes over-treatment has been inadvertently given and improvement will occur when it is stopped or decreased in frequency.

7. *Never Force an Elbow Joint.* Active motion within the limits of pain is the ideal exercise. Forced motion causes more trauma and pain, limits motion and tends to retard the recovery of function.

Discussion

In fractures about the elbow joint it is essential that treatment be begun as early as jossible, and that the reduction be absolutely maintained. I do not agree with Böhler that these fractures should be immobilized for six weeks. Motion can be started much earlier if care is taken that the movement is not painful and is carried out actively and with absolutely no forcing. Prolonged immobilization itself may cause protracted disability. This is well illustrated by the following case. In a boy 13 years of age the normal epiphysis was apparently mistaken for a fracture of the olecranon. A cast was applied in the emergency room with the elbow at right angles and the patient sent home. Four weeks later he appeared in the out-patient department where the cast was removed. At that time he could extend his elbow to 125 and flex it to 65 degrees. A month later his motion had not improved. Physical therapy was then started. He was given 17 treatments over a two-month period, after which he could extend the elbow to 170 and flex it to 50 degrees. Treatments were then discontinued in the belief that full function would return. In this case one month of immobilization without a fracture resulted in more than four months of disability.

In supracondylar and transcondylar fractures of the humerus our best results have been obtained by maintaining immobilization for about ten days to two weeks and then removing the splint for treatment in the whirlpool bath. This bath supplies heat and mild massage which relieves pain and reduces swelling. The patient is then instructed to flex and extend the elbow slowly and carefully as far as possible without pain. Pronation and supination are also performed in the same manner. It is extremely important that the joint should never be forced. It is stressed that treatment must never produce pain, but should relieve it to some degree. The splint is then reapplied. It is usually found that the range of motion possible without pain increases quite rapidly with physical therapy. At the end of three or four weeks of treatment, if satisfactory motion has not been obtained, it is determined by x-ray, if possible, whether the limitation is due to callus formation or some other cause.

If callus limits motion, usually at 160 to 170 degrees, treatment is discontinued and active use of the arm is advised, because full motion will return in time without active therapy other than exercise. Such management would not appreciably hasten the return of function.

Fractures of the capitellum or of the lateral condyle just proximal to it are troublesome at the best. If reduction could be obtained by closed methods the results are fairly good. However, if open reduction is resorted to as in five of our cases, the results are poor with resultant loss of carrying angle, myositis ossificans, or limitation of motion. Several of the unoperated cases also developed loss or reversal of the carrying angle. Physical therapy in these cases was prolonged and difficult.

Separation of the epiphyses of the medial or lateral epicondyle constitutes a trivial injury. All six of these cases rapidly recovered complete function regardless of whether the epiphyseal separation was reduced or not. Only two received physical treatment.

Fractures of the head of the radius present difficult problems. If they are of mild degree, immobilization at right angles for 5 to 10 days followed by active motion in the whirlpool bath will usually yield rapid return of function. However, more severe fractures of the radial head require open operation and removal of the fragments. If this is done some impairment of function is almost certain to supervene. This, however, can be reduced to a minimum by early active motion as outlined above. Immobilization after this operation performs no useful function and, in my opinion, only adds to the disability. It is essential that all fragments should be removed except those that are firmly attached to the radius.

Dislocations of the elbow with or without fracture of the coronoid process of the ulna should be treated by early motion. If the dislocation has a tendency to recur, thus indicating an extensive tear in the joint capsule and ligaments, it is well to maintain immobilization for ten days or two weeks in a right angle splint to allow healing of the tear before starting active motion in the whirlpool. However, usually only two or three days after reduction, the splint can be removed for treatment and then re-applied. It may ordinarily be discarded completely after a week or ten days. If there is marked swelling, blistering of the skin, or other evidence of soft tissue injury, treatment should be begun as early as possible, so that the swelling may be completely removed, preferably before two weeks have passed.

Severe fractures of the olecranon are commonly opened and wired or held in place with vitallium screws or heavy catgut. If the internal fixation is adequate and no immobilizing splint is used, very little or no physical therapy is required. If the elbow is immobilized in extension, physical therapy is very difficult and the treatment is prolonged. In fact, it may be impossible to secure flexion without manipulation under anesthesia, in which case the fracture is usually torn apart again, and fibrous union or non-union results. Re-operation may become necessary. If immobilized in flexion at right angles physical therapy follows much the same technic outlined above and is usually not unduly prolonged. Again it is important that motion be started as early as possible and that forced motion be absolutely prohibited.

Summary and Conclusions

Methods of treating fractures and dislocations about the elbow joint are presented which are based upon one hundred eighty cases with a careful follow-up. One hundred five of these received physical therapy in some form.

The important principles are: (1) Treatment should be started as early

as is consistent with maintenance of the reduction; (2) absolutely no pain should be caused by the treatment at any time; (3) swelling should be relieved at once; (4) exercises should be entirely active; (5) frequent x-ray rechecks should be made; (6) treatment should not be continued indefinitely, and (7) any force applied to an injured elbow must be scrupulously avoided.

709 Medical Arts Building.

Discussion

Dr. W. H. McGaw (Cleveland): Dr. Knapp's excellent presentation of an important subject deserves much commendation and the points stressed should be understood by all physical therapy departments and fracture clinics. The excessive swelling following severe fractures is always a great problem. I believe much of the disability caused by dense adhesions and excessive callus is apt to follow this swelling and repeated manipulations and reductions tend to increase this edema. The treatment and prevention of this swelling deserves much attention. Early reduction is always the best and should always be carried out under the fluoroscope. The circulation must not be impaired by acute flexion. The dependent position of the arm in a sling also favors congestion.

To treat these conditions we have frequently suspended the arm in a cast in an over-head sling with the patient in bed. Zeno's arrangement of upward suspension with a wire through the olecranon is another similar method. At times it has proved of great value to keep the arm of an ambulatory patient on an airplane splint till the swelling subsides. After reduction, elevation and ice bags can be used with benefit to control swelling. It cannot be stressed too often that only active motion within the limits of pain, is indicated after an elbow fracture. For chronic limitation of extension resistive exercises are indicated as described by Dr. Knapp.

Dr. K. G. Hansson (New York): If I were asked to write a paper on physical therapy in fractures about the elbow joint, I should copy Dr. Knapp's contribution. It is in such perfect agreement with my own experience that I have very little to add, and therefore shall only repeat a few of the things he has said merely for emphasis.

Whenever we deal with fractures let us not forget that we are treating a human being as a whole and that this patient has an extremity which has a fracture. Besides the break in the continuity of the bone, we have damage to the soft tissue about the fracture. Our duty is to restore complete function of the bone as well as of the adjacent joints and soft parts. When these considerations are applied to the elbow joint, let us be more specific than we usually are. A supracondylar fracture is very different from that of an olecranon or of one of the head of the radius. In the first type we must look out for injury to the ulnar nerve or the epiphysis and ossifying hematomas. In the second one, due to immobilization in extension, we must concentrate on flexion. In the third one, supination and pronation is usually interfered with.

Dr. Knapp brings out in his first table the fact that supracondylar fractures and separation of the epiphysis of epicondyles are most common in children and fractures of the head of the radius and olecranon are usually encountered in adults. In table 2, he brings out another point that should be emphasized; namely, fractures of the head of the radius and dislocations require most treatment and separation of epiphysis least. I believe many fractures of the head of the radius are best treated with a sling and physical therapy. Unless this is well supervised, it is often better not to advise such therapy in dislocations. This is where we see the greatest number of ossifying hematomas.

In discussing reduction, I used to think this was not so important in children who seemed to compensate for even gross defects in this condition. However, I should like to advise caution especially in injuries to the epiphysis where deformity may increase unless it is properly reduced. I do not remember seeing any non-pathologic non-union about the elbow and we should worry more about the possibility of ossifying hematomas. In a series of 100 cases that I presented about ten years ago, I found 4 per cent ossifying hematomas and 2 per cent nerve lesions. Whenever our measurements show decrease of function in spite of treatment, one should suspect ossification and insist on x-rays.

I condemn with Dr. Knapp the passive movement and forceful manipulation under anesthesia; heat and active movements constitute the principle treatment. Carrying of weights is unphysiologic and should be condemned. The healing of the fracture and the return of function should go hand in hand and begin simultaneously. It is difficult to lay down rules and each case should be treated as early as possible.

Dr. Miland E. Knapp (closing): It is gratifying how well we are agreed upon the physical therapy management of elbow-joint trauma. I should like to point out that in our group of 150 elbow cases there were only five that showed ossification in some degree, which isn't far from the figures of Dr. Hansson. None of them had ulnar nerve lesions that were of any great importance. We had one patient with a very severe supracondylar or T-fracture of the humerus in a girl, who fell off a horse. She had a radial injury which was a little bit unusual, but cleared up rather promptly in a month or so.

OPTIMAL DOSAGE IN SHORT WAVE DIATHERMY *

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CHICAGO

Short wave diathermy is one of the most valuable aids in physical medicine. Conventional practice accepts it as satisfactory treatment wherever deep heat is indicated; that certain established contraindications must be regarded; that the tolerance of the tissues for heat is a guide for intensity input; and that treatment be repeated as often as clinically "indicated." This "indication" often is a matter of arbitrary decision or economic convenience.

Short wave diathermy has been long regarded by critics as a practice governed by empiricism. By a thorough consideration of the indications, contraindications, and the conditions determining optimal dosage, the conclusion may be reached that short wave diathermy can be accepted not only as an aid but as a definite remedial agent for the process of physical recovery.

Short wave diathermy has been used by me in the treatment of a wide variety of acute and chronic pathologic conditions. Up to the present, 27,676 treatments have been given by me with the application of the determinants of optimal dosage as discussed in this paper. The following illustrative cases are briefly reviewed as typical of results obtained by this method. This clinical study demonstrates the chief indications for, and contraindications to, short wave diathermy.

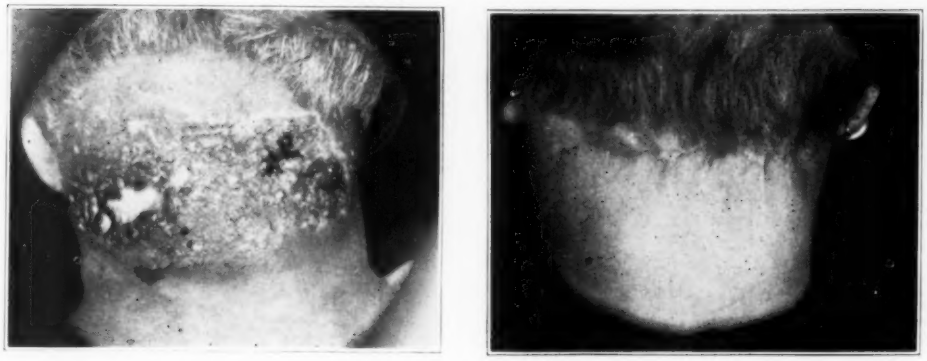
Case Reports

Case 1684. — Mrs. S. W., aged 59, diagnosed as carbuncle of neck. This infection was present for two and one-half weeks before short wave therapy was instituted. In spite of the continued application of moist heat the lesion became progressively worse, fever remained high, toxicity and pain were severe. The treatment essentially consisted of the application of an electromagnetic field, applied with a 12-inch disc, low intensity, twenty minutes every hour, twenty-four hours per day for fourteen days, then twelve hours for each of the remaining five days. The only other treatment was superficial dressings. Severe pain was alleviated after the first, and disappeared altogether after the third session. General symptoms of fever, rapid pulse, and the like subsided promptly. Complete sloughing occurred by the thirteenth day; granulations appeared on the fourteenth day and were completed to a level with the skin margins on the nineteenth day. Subsequent epithelization was accomplished with careful dressings of overlapping narrow strips of adhesive tape during a period of six weeks. Total period of hospitalization was nineteen days (fig. 1).

Other carbuncles of equal severity have been treated in like manner and with equally good results. The location of these has been over the scapula, the buttocks, and the groin. Some of these patients had diabetes.

Case 1964. — Mr. M. L., aged 26, was diagnosed after admission as cellulitis of the face with threatening meningitis. The infection began nine days before diathermy was instituted. The symptoms became progressively worse during that time in spite of the application of hot wet dressings. During the 24-hour period before diathermy was ordered the patient began to show signs of meningeal irritation. He had a continued high septic fever and was severely toxic. Treatment was given by the electromagnetic field with a 12-inch disc, low intensity, twenty minutes every hour, day and night for five days, then twelve hours per day for three days. A slight dermal incision was made prior to the initiation of this therapy. The symptoms of severe toxemia and signs of meningeal irritation subsided during the first twenty-four hours. The swelling began to disappear promptly and cleared up early the fifth day. Treatment was continued for three days after the appearance of a persistent normal temperature (fig. 2).

* Read before the Eighteenth Annual Meeting of the American Academy of Physical Medicine, Richmond, Virginia, April 25, 1940.



A B

Fig. 1. — *A*, appearance of lesion at beginning of diathermy management; *B*, end-result, six weeks later.

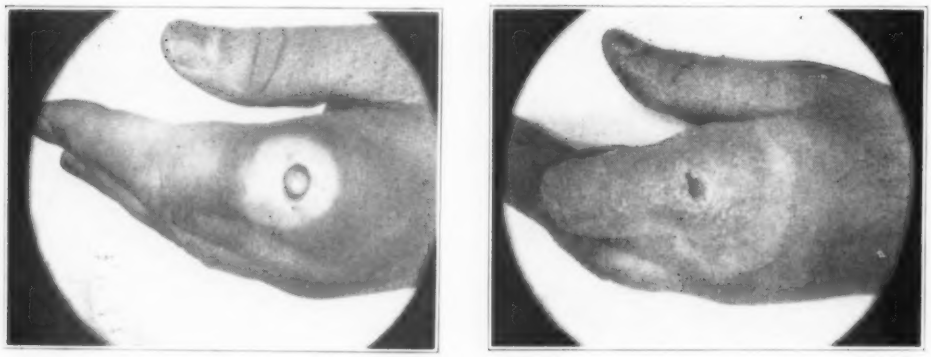
Case 302. — Mr. J. P., aged 58, entered with a diagnosis of infected hand with lymphangitis and axillary adenopathy. This hand was treated in a conventional manner, first with a simple drainage at site of entry. The lesion progressed very slowly for one week, during the next two weeks hot wet dressings were applied to the hand and forearm about sixteen hours per day. At the end of the third week, the lymphangitis and adenopathy suddenly appeared and were ushered in by chills and fever. At this time treatment by electromagnetic induction was instituted, with the application of a long double loop cable extending from the hand to the shoulder. The electromagnetic field was applied twenty minutes every hour day and night for four days, then twelve hours each of the following

A B

Fig. 2. — *A*, cellulitis of face as it appeared at the beginning of diathermy management; *B*, complete recovery observed on the fifth day.

three days. The fever, the lymphangitis and axillary lymphadenopathy subsided at the end of the first twenty-four hour period. The photographs show the progress. Healing was completed at the beginning of the sixth day. A few weeks later it was discovered that this patient had a blood sugar content of 352 mg., which might explain the failure of recovery during the first few weeks with conventional management, but it is of special interest to observe the prompt recovery effected by the short wave method under the same conditions (fig. 3).

Case 627. — Mr. F. R., aged 36, was admitted for non-union of the tibia and fibula of nine months duration. During that period the patient had quite adequate care. He had no constitutional disease. In spite of a negative Wassermann report, a course of neosalvarsan was given augmented by 24 injections of calcium, parathyroid extract and viosterol. There was no apparent reason for the non-union. At the tenth month, short wave diathermy was started. At first two 2-hour treatments were given daily; the patient remained ambulatory on crutches. After two and one-half weeks he chose to have but one treatment daily. No other therapy other than good immobilization was administered. He was given a total of 82 two-hour treatments in 69 days. The progress and result are shown in the illustrations. At the end of this time the patient was bearing full weight on the leg and using only a cane for assistance (fig. 4).



A B

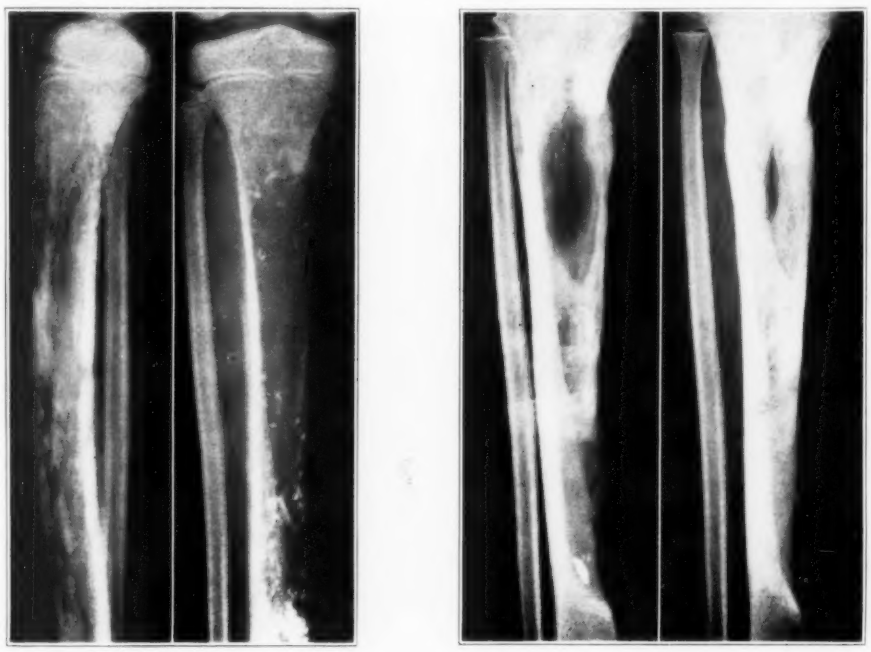
Fig. 3. — *A*, appearance of lesion at beginning of diathermy management; *B*, completely healed on the sixth day.

CASE 1709. — Master C. S., aged 9, was eventually diagnosed as osteomyelitis of the tibia. The patient entered the hospital complaining of severe pain in the leg. No local signs of inflammation were evident and the x-ray was negative. Short wave diathermy was given with a low intensity for thirty minutes daily. After ten days a subperiosteal abscess

A B

Fig. 4. — *A*, tibia and fibula after non-union of nine months standing; *B*, complete union after ten weeks of diathermy management.

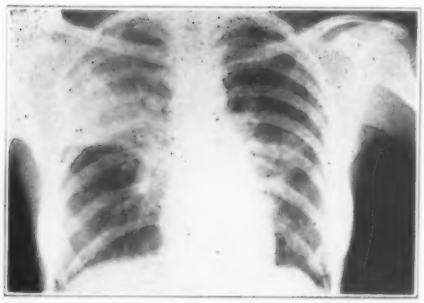
localized and was opened and drained. The diathermy was continued as before. On the thirtieth day the x-ray revealed a severe advanced osteomyelitis of the tibia. A radical operation was performed leaving only a very thin shaft of bone with the attached periosteum. Short wave diathermy in the postoperative period was given for thirty minutes every two hours, six treatments daily, thus producing a continual active hyperemia for twelve consecutive hours daily. The roentgenograms show the progress. At the fifth month the boy fell and sustained a fracture as seen in the x-ray; the nature of this fracture indicated the hard quality of the new bone formation. The leg was placed in a cast for one month during which time no short wave diathermy was used. After removal of the cast treatment by diathermy was instituted as before. The patient had a total of five months' treatment during a six month period. This case illustrates the value of short wave diathermy in promoting a rapid osteogenesis. Only time will tell the ultimate effect upon the osteomyelitis toward a cure (fig. 5).



A B C D

Fig. 5. — *A*, diagnostic x-ray showing osteomyelitis of tibia; *B*, appearance of tibia after radical surgical removal of infected bone; *C*, after eight weeks treatment with electromagnetic induction. Note rapid filling in and the appearance of structural markings in the new bone; *D*, after twenty-four weeks of treatment with electromagnetic field, regeneration of bone completed.

Case 1669. — Miss M. K., aged 25. This patient was very sick for five days before entering the hospital. The fever and toxicity and respiratory symptoms indicated pneumonia, but the physical findings were atypical. On the sixth day the patient coughed up fourteen ounces of exudate in twenty-four hours. A clinical diagnosis of lung abscess was made and the patient was brought to the hospital. This exudate was reported by the pathologist to be typical lung abscess fluid. The volume of exudate produced continued for days. X-ray study did not support the diagnosis of abscess, no cavity could be demonstrated at any time and the solid shaded area did not seem to conform to that usually seen in abscesses. Diagnosis of interlobar empyema, and pulmonary infarct, were also suggested. An associated pneumonic congestion was evident. Two days after the diagnostic x-rays, short wave diathermy was instituted. Treatment was given 20 minutes per hour twenty-four hours per day for twenty consecutive days. The pulmonary distress was markedly relieved after the first day. After several days the severe toxemia abated and the volume of the exudate decreased definitely. The temperature dropped to normal on the seventh day and remained so. The treatment was continued until the x-ray no longer showed any decrease in the densely shaded area in the upper chest. So long as this shaded area decreased in size we believed that the treatment was causing a decrease of an inflammatory process. On the tenth day lipiodol was instilled into the opposite lung but no evidence of bronchiectasis was discovered to account for the volume of exudate produced earlier. The chest was checked by x-ray six months later and found to be entirely negative (fig. 6).



A

B

C

D

E

Comment

We see that the cases in this series vary widely in the tissues involved; in their severity and in their etiologic factors; some being infectious and others traumatic. Short wave diathermy was used as the sole remedial agent for tissue recovery in each instance; the benefits are obvious. Inasmuch as a single remedial agent proved to be an effective aid in tissue recovery it be-

Fig. 6. — *A*, diagnostic x-ray showing location and density of inflammation; *B*, diagnostic x-ray showing location and density of inflammation; *C*, after two days on diathermy management. Note decrease in size of zone of inflammation; *D*, after ten days on diathermy management. Note residual zone of inflammation; *E*, after twenty days on diathermy management. Note completeness of recovery of zone of inflammation.

comes evident that there must be one common condition which responds to this therapy.

This one condition is inflammation. Short wave diathermy is effective in overcoming the passive congestion of any inflammatory reaction by establishing and maintaining an active hyperemia, thus improving physiologic well-being and promoting physical recovery. In my judgment, short wave diathermy is a remedial agent for the reaction of inflammation when optimal dosage is employed and when inflammation is the chief indication.

It is well to recognize that in our chief indication for diathermy, namely, inflammation, we find edema to be our chief contraindication. The severity of the edema is always a definite but also a relative contraindication. A general rule of technic which must be remembered is: the greater the edema, the greater the caution regarding the power input per unit tissue volume. In other words, the greater the edema, the less is the tissue tolerance for heat, and the lower the intensity input requirement for safe, effective treatment (fig. 7).

In determining the power input per unit tissue volume, the limit of tolerance of the normal skin for heat is often used as a guide. We do well to remind ourselves that we confront a pathologic process, which presents the relative contraindication edema. Edematous tissue does not have a normal circulation to dissipate the heat induced by diathermy; therefore an accumulation of heat may occur and may not only hinder recovery but actually retard healing because of tissue damage due to overheating. Thus we understand that a power input per unit tissue volume which is equal to the physiologic limit of tolerance for heat of the normal skin may be a harmful dose for the edematous inflammatory tissue lying beneath. Therefore, the information obtained on careful clinical examination must be coupled with a knowledge of the tolerance dosage for normal tissue in order to determine an optimal technic in any given case. It is obvious that this responsibility must be assumed by a physician (fig. 8).

Optimal dosage is that which will produce the desired physiologic effect with the least quantity of the therapeutic agent. In the case of short wave diathermy the desired physiologic effect is the establishment and maintenance of active hyperemia. Hence optimal dosage is that power input per unit tissue volume which is no greater than that required to establish and maintain an active hyperemia. The technic to produce the desired effect is

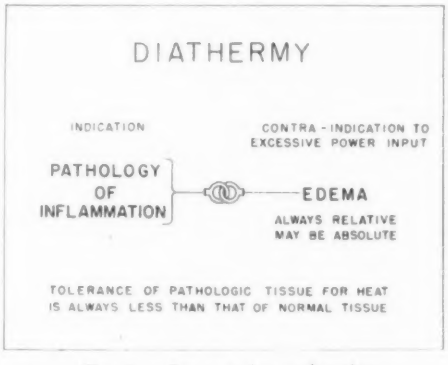

DIATHERMY
INDICATION
CONTRA-INDICATION TO EXCESSIVE POWER INPUT
PATHOLOGY OF INFLAMMATION
EDEMA
ALWAYS RELATIVE MAY BE ABSOLUTE
TOLERANCE OF PATHOLOGIC TISSUE FOR HEAT IS ALWAYS LESS THAN THAT OF NORMAL TISSUE

Fig. 7. — See text for explanation.

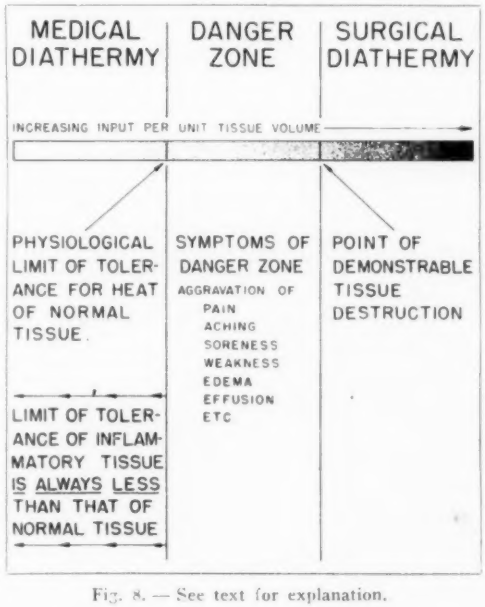


Fig. 8. — See text for explanation.

determined by the power input per unit tissue volume, the time of application, and the frequency of application (fig. 9). This means that the total

power input per unit volume of the pathologic zone must be equal to the sum of the power input per unit volume to induce and maintain the desired active hyperemia, that necessary to compensate for heat loss by circulation, and that necessary to compensate for loss by radiation, convection, and the evaporation of perspiration. Insulation to prevent loss of heat and proper distribution of the electrical input permit the maintenance of the desired local hyperemia with a minimal input per unit tissue volume and prevent excessive heating of the pathologic zone. In the following diagrams the relationships existing between the total power input per unit volume of the pathologic zone for various types of application are symbolically expressed.

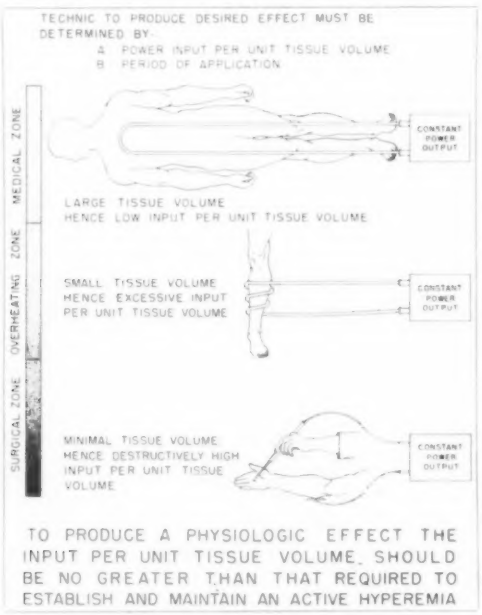

TECHNIC TO PRODUCE DESIRED EFFECT MUST BE DETERMINED BY-
A POWER INPUT PER UNIT TISSUE VOLUME
B PERIOD OF APPLICATION
SURGICAL ZONE
OVERHEATING ZONE
MEDICAL ZONE
CONSTANT POWER OUTPUT
LARGE TISSUE VOLUME HENCE LOW INPUT PER UNIT TISSUE VOLUME
SMALL TISSUE VOLUME HENCE EXCESSIVE INPUT PER UNIT TISSUE VOLUME
CONSTANT POWER OUTPUT
MINIMAL TISSUE VOLUME HENCE DESTRUCTIVELY HIGH INPUT PER UNIT TISSUE VOLUME
CONSTANT POWER OUTPUT
TO PRODUCE A PHYSIOLOGIC EFFECT THE INPUT PER UNIT TISSUE VOLUME, SHOULD BE NO GREATER THAN THAT REQUIRED TO ESTABLISH AND MAINTAIN AN ACTIVE HYPEREMIA

Fig. 9. See text for explanation.

Clinicians have been seeking some simple direct method of dosage determination for ready use in actual practice. A measuring device, such as a high frequency wattmeter is an invaluable aid in observing the exactness of a clinical application of high frequency energy, but cannot be used as a dose meter (dosimeter) because clinical judgment is an absolute necessity in the determination of dosage. A wattmeter merely measures the total power absorption in a given field but cannot measure the power input per unit tissue volume which after all is the ultimate determining factor in dosage.

Total tissue volume and total power input together determine the power input per unit tissue volume, but inasmuch as this volume in clinical practice cannot be determined, and since it varies with every patient and every clinical application of the short wave diathermy field, we cannot know the exact distribution of the total power input and therefore cannot accurately in a practical measure determine the power input per unit tissue volume. The rate of circulation in the body also cannot be determined in the pathologic tissue under treatment, but it definitely influences the effect of the power absorbed and both are in a state of continual change during the process of tissue recovery. The greatest limitation to power input from the viewpoint of safety is the presence of edema, and no inflammatory process is ever without edema, the degree of which is also an unknown, undeterminable, and inconstant variable as related to power input.

The actual temperature rise in the normal tissues as determined in clinical

research is only a single observation and is of no value in clinical practice because we are treating pathologic tissues which have a lesser heat tolerance; because there is no method of clinical depth heating measurement; because the same temperature rise can be obtained with variable technics of power input, time of application, and the method of short wave diathermy as well as the physical technical application of the diathermy field; and finally because there is no evidence at hand to indicate any specific thermal action which would support the practice of elevating the tissue temperature to any certain degree.

Inasmuch as the pathologic condition demanding treatment is the sole determinant of dosage, and inasmuch as there are so many variables in the pathologic field treated; and as the hand of a technician adjusts dials and meter readings according to a prescription, it becomes increasingly clear that the basic determination of optimal dosage must be the result of expert clinical observation and judgment.

The physiologic effect desired may be judged by the observation of the objective changes in the tissues being treated. When heat is induced in the tissues nature's first response is a change favoring heat dissipation to prevent overheating. This causes an opening-up of the vascular bed and in many cases a coincident increase in pulse rate, thus tending to augment the rate of blood flow. When this adaptation has reached its limit and additional heat is induced, the sweat glands are called into action. Therefore, when sweating occurs we can be sure that there is maximal hyperemia beneath. And, conversely, we may say that if no sweating occurs we cannot be sure that a maximal hyperemia has been induced. The incidence of sweating, then, is a reliable clinical guide for judging the power input per unit tissue volume in any given case and a meter attached to the machine merely permits recording the treatment and enables one to repeat the same procedures when such is desirable without repeating the observations which originally determined the optimal dosage.

Even after a wattage input has been measured in a given case, this same input cannot be arbitrarily employed in a similar case due to the variance of the severity of the limiting contraindication present, namely, edema. Only expert clinical judgment can determine the proper power input.

There are, however, two technical variations which must be mentioned which would not permit the observation of sweating to be a reliable guide to optimal dosage. First, when an excessive power input per unit tissue volume is used, the overheating may be so rapid as to interfere with the normal adaptation in the tissues to heat dissipation. In this instance severe overheating may occur without sweating. Second, when insulation against heat loss is not used, mild sweating may be unobserved because the rate of evaporation equals that of sweat elimination. Thus moderate overheating continues throughout the treatment. Inasmuch as this is the greatest danger in the application of short wave diathermy, it is of utmost importance to avoid its occurrence.

Insulation against loss of heat and distribution of electrical input permit the maintenance of the desired local hyperemia with a minimal electrical input per unit tissue volume and prevent excessive heating of the pathologic zone. Figure 10 presents the reasons of technical advantage but there are also reasons of clinical advantage for so doing. The process of inflammation often produces associated inflammation or functional disturbances in contiguous tissues which are frequently regarded as of lesser importance. A good example of this may be seen in lobar pneumonia where there is a severe congestion of the non-pneumonic lung tissue. In such a case localization of the diathermy to the pneumonic lobe will not produce a satisfactory relief from cyanosis and dyspnea because the efficiency of pulmonary

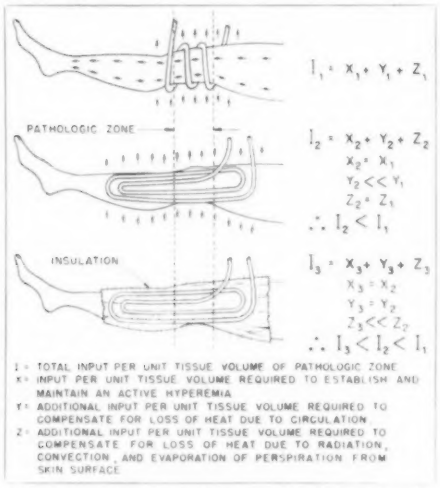

PATHOLOGIC ZONE
INSULATION
$I_1 = X_1 + Y_1 + Z_1$
$I_2 = X_2 + Y_2 + Z_2$
$X_2 = X_1$
$Y_2 << Y_1$
$Z_2 = Z_1$
$\therefore I_2 < I_1$
$I_3 = X_3 + Y_3 + Z_3$
$X_3 = X_2$
$Y_3 = Y_2$
$Z_3 << Z_2$
$\therefore I_3 < I_2 < I_1$
I = TOTAL INPUT PER UNIT TISSUE VOLUME OF PATHOLOGIC ZONE
X = INPUT PER UNIT TISSUE VOLUME REQUIRED TO ESTABLISH AND MAINTAIN AN ACTIVE HYPEREMIA
Y = ADDITIONAL INPUT PER UNIT TISSUE VOLUME REQUIRED TO COMPENSATE FOR LOSS OF HEAT DUE TO CIRCULATION
Z = ADDITIONAL INPUT PER UNIT TISSUE VOLUME REQUIRED TO COMPENSATE FOR LOSS OF HEAT DUE TO RADIATION, CONVECTION, AND EVAPORATION OF PERSPIRATION FROM SKIN SURFACE

Fig. 10. Diagrammatic representation of the influence of insulation and of the distribution of power input on the required power input per unit volume of tissue in the pathologic zone to induce and maintain an active hyperemia. For explanation of formula see text.

ventilation is not readily increased by the treatment. But when diathermy is applied to the non-pneumonic tissue as well, then the active hyperemia induced relieves the passive congestion in this non-pneumonic tissue and the cyanosis and dyspnea are quite promptly relieved. Pulmonary ventilation is sufficiently improved to permit increased, often adequate, oxygenation of the blood by breathing merely atmospheric air.

Another example of the value of treating tissues secondarily involved, and adjacent to a pathologic area is given in the following case. A patient with a non-union of the tibia and fibula, at the junction of the middle and lower thirds, of fifteen months duration volunteered the information after ten daily diathermy treatments that the toe nails on the foot distal to the fracture had not grown during the previous fifteen months and since the diathermy was being applied to the extremity the nails had grown sufficiently to require cutting.

Thus we see that the distribution of the power input is not only a safety factor against overheating the pathologic tissues, but also is desirable in order to overcome the associated passive congestion and trophic changes occurring in contiguous tissues.

Duration of Treatment

After having determined the power input of the short-wave diathermy to a pathologic zone it becomes necessary to establish how long this input should be continued for a single treatment and how often this procedure should be repeated. Inasmuch as a physiologic improvement is desired it becomes necessary to administer the therapeutic agent for such period of time and as often as is required to effect an accumulative benefit. Again, the decision rests upon careful clinical observation and judgment. Figure 11 presents conventional treatment schedules which are considered on a basis of the number of treatments per week. From this illustration it is clearly evident that the aggregate duration of the hours of induced active hyperemia is exceedingly small compared to the hours of no induced active hyperemia. There have been numerous examples in my experience with a treatment schedule in which a single application of short wave diathermy produced a transient improvement, but the pathologic process reverted to

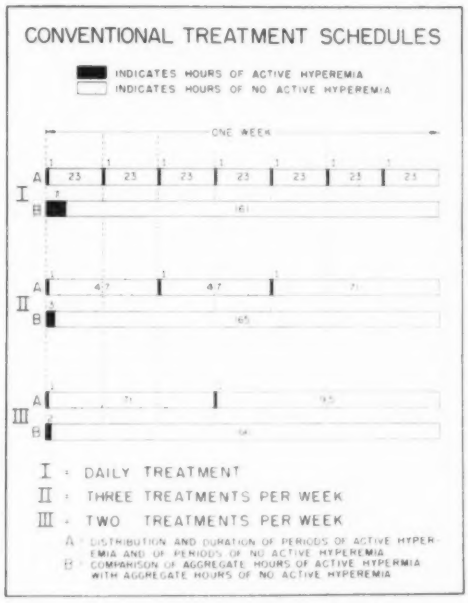
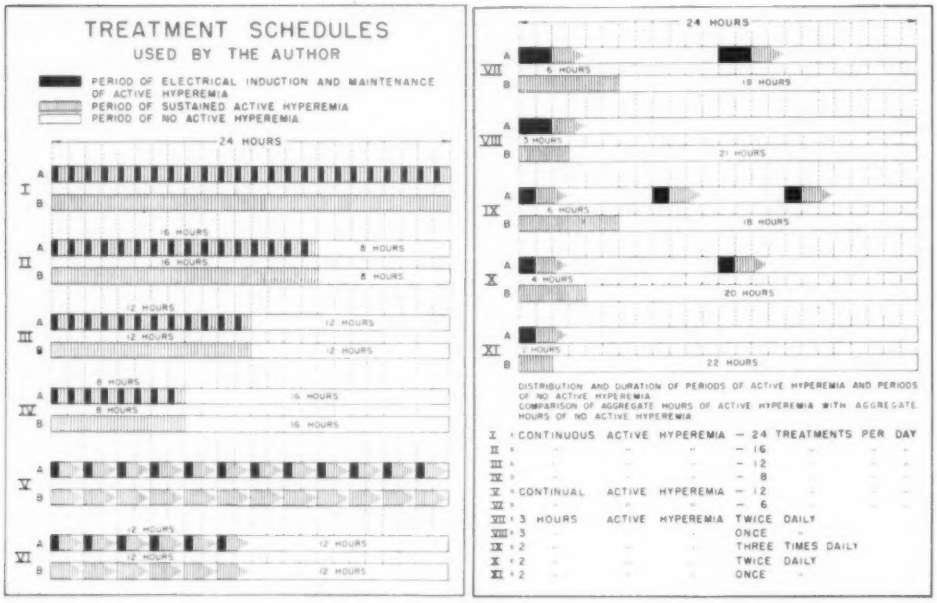

CONVENTIONAL TREATMENT SCHEDULES
INDICATES HOURS OF ACTIVE HYPEREMIA
INDICATES HOURS OF NO ACTIVE HYPEREMIA
ONE WEEK
I
II
III
A
B
I = DAILY TREATMENT
II = THREE TREATMENTS PER WEEK
III = TWO TREATMENTS PER WEEK
A = DISTRIBUTION AND DURATION OF PERIODS OF ACTIVE HYPEREMIA AND OF PERIODS OF NO ACTIVE HYPEREMIA
B = COMPARISON OF AGGREGATE HOURS OF ACTIVE HYPERMIA WITH AGGREGATE HOURS OF NO ACTIVE HYPEREMIA

Fig. 11. — See text for explanation.

its original severity before the second treatment was given. In such instances accumulative benefit was either not evident or the improvement was so slow as to make the procedure economically unsound. When such failures in treatment were given short wave diathermy according to my treatment schedules as shown in figure 12 (a, b), recovery was satisfactory and surprisingly prompt.

Consider the fact that in the employment of short wave diathermy the therapeutic agent is heat. As long as there seem to be no specific advantages in the electric lines of force, in the wavelength, or in any specific thermal effect, we may divorce short wave diathermy from the expectancy of any miracle and use it according to the rules governing the application of heat. The depth heating characteristic of short wave diathermy surely is of singular advantage but we nevertheless are applying the simple effective agent, namely, heat.

If this conventional schedule of treatment by diathermy is adequate, then likewise it should be quite satisfactory to apply heat by hot wet applications for one hour, two or three times weekly. A commonly accepted treatment for an infected extremity with lymphangitis is the continuous application of heat, by means of hot wet dressings, and in order to insure the safety and adequacy of the application we even justify the expense of twenty-four hour special nursing service. If this procedure is reasonable and desirable then there is just as much good sense in the use of short wave diathermy for the same purpose, namely, of applying heat. Short wave diathermy in such a case is superior to hot wet dressings; the hyperemia induced is more adequate at all times and furthermore there is no waterlogging of the skin to offer a handicap for rapid recovery. When an optimal power input to the pathologic tissues is employed, there is no contraindication to the maintenance of a continuous or a continual active hyperemia by the application of short wave diathermy. The cases presented in this article clearly testify in favor of the treatment schedule used by me as shown in figure 12 (a, b). The wide range of treatment schedules shown in this chart illustrates the varied adaptations used to meet the requirements


TREATMENT SCHEDULES
USED BY THE AUTHOR
PERIOD OF ELECTRICAL INDUCTION AND MAINTENANCE OF ACTIVE HYPEREMIA
PERIOD OF SUSTAINED ACTIVE HYPEREMIA
PERIOD OF NO ACTIVE HYPEREMIA
24 HOURS
16 HOURS
8 HOURS
12 HOURS
DISTRIBUTION AND DURATION OF PERIODS OF ACTIVE HYPEREMIA AND PERIODS OF NO ACTIVE HYPEREMIA.
COMPARISON OF AGGREGATE HOURS OF ACTIVE HYPEREMIA WITH AGGREGATE HOURS OF NO ACTIVE HYPEREMIA
I = CONTINUOUS ACTIVE HYPEREMIA — 24 TREATMENTS PER DAY
II = — 16
III = — 12
IV = — 8
V = CONTINUAL ACTIVE HYPEREMIA — 12
VI = — 6
VII = 3 HOURS ACTIVE HYPEREMIA TWICE DAILY
VIII = 3 ONCE
IX = 2 THREE TIMES DAILY
X = 2 TWICE DAILY
XI = 2 ONCE

A B

Fig. 12, A and B. — See text for explanation.

of individual cases. The range of clinical application extends from the treatment of a severe threatening infection down to management of a mild ambulatory patient with a non-disabling complaint.

For this scheme of treatment which requires prolonged or frequent applications of short wave diathermy I have used the electromagnetic induction field for several reasons. First, on account of the physical adaptability of the cable to secure the desired distribution of the power input; and also its applicability to all anatomic parts. Second, on account of the established heating characteristics of the electromagnetic field, namely, dominant production of heat in the vascular tissues and the maintenance of the normal heat gradient from muscle, to fat, to skin. My work is done with a low power input in all cases. Total wattage input to the patient has been measured, recently, with a high frequency wattmeter for all of the various applications used. The total wattage input is low and varies widely according to application as shown in table 1.

Table 1. — *Total Power Input Measured With a High Frequency Wattmeter.*

Treatment	Application	Watts
Head	12″ Disc	20- 35
Chest	12″ Disc	35- 70
Pelvis	12″ Disc	50- 75
Back (Lumbar)	Pancake Coil (3 turns)	45- 85
Lower Extremity	Long Single Loop	80-110

The measurements given in table 1 represent the total power input expressed in watts. These readings are measurements of my regular treatment technic. The total values are desirably low and when we estimate the tissue volume to which this total power input is distributed, we find a very small power input per unit tissue volume in all cases. The variation in wattage readings indicates the requirement of using different intensities according to the clinical judgment at the time of each treatment. It is im-

portant to note by this study that a constant dial reading on the diathermy machine gives different readings on the wattmeter according to the application of the electromagnetic field. For example, when applying the field to the lumbar region, the chest, the pelvis, the leg, each with the same dial setting on the apparatus, the wattmeter showed wattage readings of 44, 70, 58, and 86, respectively. Thus we see that the power input cannot be satisfactorily determined by the control dial reading alone, on any short wave apparatus, nor even by a high frequency wattmeter unless the distribution of the power input is taken into consideration and the severity of the pathologic process judged clinically. The optimal power input per unit tissue volume is secured by proper application of the induction cable and by adjustment of intensity to a value determined by clinical judgment. I have used the electromagnetic induction field in clinical research for the past five years and have adjusted and varied the intensity input on the basis of clinical judgment, using the lowest power input in each case which would produce a favorable result. Such individualization is amply rewarded by the results obtained.

Summary and Conclusions

1. The chief indication for short wave diathermy is the presence of inflammation.

2. The chief contraindication for short wave diathermy is edema.

3. This indication and contraindication are inseparably joined together; therefore a relative limitation upon intensity input is always present.

4. The desired physiologic effect from short wave diathermy is the establishment and maintenance of an active hyperemia.

5. The depth heating characteristic of short wave diathermy is of singular advantage, but nevertheless we may be guided in its application by the general rules governing the use of the simple, effective therapeutic agent, namely, heat.

6. The tolerance of inflammatory tissue for heat is always less than that of normal tissue; therefore the tolerance of normal tissue for heat is an unreliable and unsafe guide for determining the power input per unit tissue volume.

7. When optimal technic is employed, the incidence of sweating is a reliable guide for judging the power input per unit tissue volume.

8. A high frequency wattmeter is a valuable aid in determining total power input, but it can not be considered a "dose meter" on account of the presence of underterminable variables which must be evaluated by clinical judgment.

9. Optimal dosage is the smallest power input per unit tissue volume which will establish and maintain an active hyperemia, the application of which must endure for such time and be repeated at such intervals as are necessary to produce an accumulative beneficial effect.

10. Optimal dosage is determined by the power input per unit tissue volume, and the period of application and of re-application.

11. To produce a physiologic effect the power input per unit tissue volume should be no greater than that required to establish and maintain active hyperemia.

12. The greatest danger of short wave diathermy is overheating; therefore its occurrence should be avoided.

13. Insulation against loss of heat and distribution of the electrical input permit the maintenance of the desired local hyperemia with a minimal electrical input per unit tissue volume and prevent excessive heating of the pathologic zone.

14. Distribution of the power input to the tissues beyond the pathologic zone is of advantage in overcoming associated pathologic and trophic disturbances in contiguous tissues.

15. When an optimal power input to the pathologic zone is employed, there is no contraindication to the maintenance of a continuous or continual active hyperemia by the application of short wave diathermy.

16. For prolonged and frequent applications of short wave diathermy the electromagnetic induction field is the method of choice because of its physical adaptability to secure desired distribution of the power input, its applicability to all anatomic parts, and its established heating characteristics.

Short wave diathermy is a most valuable aid in promoting physical recovery of tissues, and when optimal dosage is employed it is in fact a remedial agent for the process of inflammation.

Optimal dosage is determined by a knowledge of the nature of the pathologic process under treatment, the regulation and performance of the diathermy apparatus, and the experience gained from successful treatments; all these properly balanced formulate the only reliable "dose meter," namely, expert clinical judgment for the determination of optimal dosage of short wave diathermy.

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EVALUATION OF HYPERPYREXIA IN GENERAL MEDICINE *

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The evaluation of any method of treatment in its relation to general medicine must include: (1) possible specificity for particular diseases; (2) value as supplementary therapy to medical treatment; (3) any generalized non-specific benefits; (4) the risk to the patient's life or health; (5) the economic factors affecting availability to the average patient of medium means or less, and (6) the possibilities for further development and broadened application of the therapeutic medium.

We first became interested in hyperpyrexia for the treatment of intractable asthma, since we had a number of patients whom we had been unable to relieve by the usual allergic approach. Reports in the literature[1] both before that time and since have shown that hyperpyrexia in such cases has produced about 30 per cent complete remission, 37 marked improvement, 8 slight improvement, with 25 per cent no benefit. Usually, however, most of these conditions recurred within a year, generally within a few weeks. Still, even a brief respite is welcome to such sufferers, and with this in mind,

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we obtained a cabinet type of machine,* using hot water vaporized air to induce fever.

The first year we had this apparatus, we treated all patients who were sent to us by colleagues for fever therapy regardless of their complaint, but of course, with careful consideration of their cardiac condition and other contraindications. This was nearly eight years ago, when the lay press was filled with discussions of so-called "friendly fever" and the professional literature was not nearly so well defined concerning the indications as it is today. Our results in general have been reported in former papers,[2-3-4-5] but in this report we will restrict our observations to methods and limitations of fever therapy in office practice.

The literature on artificial fever is now so vast that a review of it is impossible in our limited space. Fortunately, part of our experience has been confirmed so far as our first two points of evaluation are concerned, that is, specificity for a given disease and supplementary values for other diseases. From the thousands of reports one could cull either typical or collective conclusions for various diseases which the general practitioner or internist frequently finds difficult to manage.

Clinical Observations

Before the days of sulfanilamide, practically all investigators were agreed that fever therapy was the most effective method for gonorrhea and its complications, including gonococcic arthritis. Neymann tabulates 590 patients, of whom 79 per cent recovered and an additional 5 per cent improved. Warren,[6] in testing the thermal death time for the gonococcus on 100 patients was able to establish negative cultures in 87 patients immediately, and in 8 others from three days to six weeks after treatment. This so far appears to be the only disease for which fever therapy is definitely established as a specific.

Since the advent of sulfanilamide, so easily administered, fever therapy has lost place, but many reports, including that of Ballenger, Elder and McDonald,[7] seem to show that artificial fever and sulfanilamide combined may give more favorable results than either medium alone. That fever alone will reach some patients resistant to sulfanilamide may well be deduced from Warren's remarkable success. The report of Burpee[8] and his colleagues on the use of theelin with fever therapy is also interesting.

Artificial fever in the treatment of syphilis has received the most publicity, due to its satisfactory results in paresis and tabes. Solomon and Kopp's[9] review concluded that in 70 to 80 per cent of patients with paresis and 50 per cent with tabes treated by artificial fever the processes have been arrested. In early syphilis virtually all reports indicate that hyperpyrexia alone is a failure. In combination with chemotherapy recovery of the patient is greatly aided by fever, as noted by Simpson[10] and others.

The results in bronchial asthma have already been alluded to. Phillips and Shikany[11] made an extensive clinical study, and they, with other writers, seem to feel that fever should be used only after all other means have failed.

In general practice, numerous individuals are seen with neuritic pains of various types and origins. Bennett and Cash,[12] at the University of Nebraska, treated 40 patients, 20 of whom were suffering with sciatic neuritis, with immediate relief, though there were some recurrences. They considered the therapy to be of distinct advantage without being specific.

Among the arthritides, Krusen and Elkins[13] consider that 30 per cent of patients with infectious arthritis might be relieved by fever, that gonococcic arthritis would respond favorably in a majority of instances, but that other

* Clark Hyperpyrexator.

types were not amenable, a conclusion in line with that of Hench and coworkers[14] in their survey of the problem.

The results in some ocular diseases treated by hyperpyrexia vie with those obtained in gonorrhea. Berris and Newman[15] report three patients with ocular syphilis, and a similar number each with gonorrheal ophthalmia, and non-specific iritis that cleared up by artificial fever, two of whom were cured by a single treatment. O'Leary[16] and others suggest that interstitial keratitis and other forms of inflammation may best respond to a combination of fever and chemotherapy.

Krusen and Elkins consider that the value of fever therapy is established in gonorrhea, dementia paralytica, ocular syphilis, neurosyphilis, intractable bronchial asthma, infectious arthritis, and neuritis. It is accepted as favorable but so far not definitely estimated in chorea, meningococcic septicemia, mycosis fungoides, rheumatic fever and undulant fever. This method is definitely unfavorable or even dangerous in subacute bacterial endocarditis, multiple sclerosis, Parkinson's syndrome and tuberculosis.

These positive results establish for artificial fever a place in medicine. Its non-specific restorative value has not been evaluated despite existing clinical data, but for the majority of patients such a consideration is of no moment. While we have had many patients report to us that treatments at low temperatures have a generally stimulative effect on their health, such subjective reactions are of minor importance in the evaluation of fever therapy.

Hazards and Risks

The risk to the patient in fever therapy properly conducted is amazingly small. Hench noted only 11 deaths in many thousands of fever sessions for gonorrheal complications, and Neymann considers a proper selection and care of patients almost absolute insurance against fatality. When one considers the usual physical debility associated with neurosyphilis, the comparative safety of the method in proper hands is all the more significant.

On the other hand, the methods so far generally used represent a physical and economic strain. The majority of treatments for gonorrhea and syphilis and their complications, as well as for asthma and some of the other diseases noted, given at 106 F. and maintained for four to ten hours involves considerable cost. They necessitate hospitalization and loss of time from work in those who are still able to pursue some activity. This places the method beyond reach of all but the rich and the indigent who are treated in the occasionally equipped private or charity hospital. Thus, the physician who would find artificial fever very valuable with many patients can utilize it only under the conditions just discussed.

When we arranged our fever therapy unit, we naturally had in mind the types that are clinically and economically available in office practice, that is, ambulatory patients of moderate means, frequently dependent on a definite income. We learned early from our own and other experimental works that treatments of four hours and longer at high temperatures were impractical for office practice and seriously interfered with the patient's routine. We arranged our unit to consist of a treatment room, recovery rooms, and shower, and since the experimental first year have tried to concentrate on disturbances that would respond to treatments of one to four hours at a temperature up to 106 F. (occasionally at higher temperatures in collaboration with a referring urologist). To date we have treated 484 patients, the majority of whom were suffering from atrophic arthritis or neuritic symptoms, and have given 4,857 treatments. Most of these have been dealt with in

our former papers, and our results are generally in keeping with those reported in the literature. Though our risks are slight compared to those involved in high-temperature, long-duration treatments, we exercise every precaution. The technician in charge is an especially trained nurse who was formerly an anesthetist, which has served to render her observations of greater value than those of nurses without such training. The physician is always in the office during the treatments. The patient is first carefully examined, and his reactions throughout the series are minutely noted. Our major complication was the denuding of some areas of decubitus in an emaciated patient. These healed without trouble.

Our unit is expensive and usually has not been profitable, but we feel that it has given benefit to many whom we could not have otherwise helped. Nearly all of the patients have been able to come to the office, take their treatment, spend a brief time to recuperate, and return to their daily work without the loss of more than half a day, usually less.

One of the drawbacks in any mode of therapy is an attempt to treat those in which it is inappropriate. Our early days contained quite a number of these, and even now we have an occasional patient whom we find to belong in some other field. We cite one such instance and also some cases which we considered interesting and appropriate for the type of fever we administer.

Case Reports

Case 1. — J. L. C., male, 46 years of age, was sent to us by an orthopedist for fever therapy. It was stated that he had pain in his left sacroiliac joint area, without limitation of motion, duration 5 years. The pain was worse now than at any previous time, and radiated at times down the left sciatic nerve. A urologist had found stones in the prostate and advised its resection. (This same urologist has recently removed stones from the prostate of another patient, and definitely cured his chronic backache.)

Detailed questioning elicited that the pain came on at irregular intervals, was quite intense, would be present for a few minutes and then disappear, to recur again 15 to 30 minutes later. The attacks would last three or four days, and then there was always soreness in the left sacroiliac region, with greater soreness forward in the left side of the abdomen. The picture suggested peristaltic pain to us. Further examination showed marked tympany in the right side of the abdomen and essentially none on the left. Roentgenologic examination revealed a retroperitoneal hernia with all of the small bowel in the right abdomen and all of the large bowel in the left. Fever therapy was obviously inappropriate. Proper care was outlined and followed, with no recurrence of pain.

Case 2. — C. J. W., male, 45 years of age, complained of pain in the left lower quadrant of the abdomen, the left sacroiliac joint and sciatic nerve. Roentgenologic examination showed a spastic and narrowed terminal descending and sigmoid colon. Proper care of the intestinal tract has relieved the intra-abdominal distress, but the sacroiliac and sciatic pain remained unaffected until fever therapy was instituted. These symptoms have been markedly alleviated, with the patient still under treatment. This is an example of the complementary use of fever therapy with general medical care.

Case 3. — J. R. C., male, 63 years of age, was referred for corneal ulcers and what appeared to be a panophthalmitis. This patient had a controlled diabetes and an asymptomatic hypertrophic arthritis. Enucleation of the eye was being considered after practically all forms of therapy had failed over a period of three months. After three one-hour treatments with a maximum temperature of 103.6 F. (oral), the eye was painless, the ulcers were healing, and the general inflammation subsided. Several other such treatments were given. Seventy-five per cent vision, which persists to date, was the result in this case.

Case 4. — F. C., male, 5 years of age, was referred for corneal ulcer. This ulcer, the result of an injury, developed into a panophthalmitis. The boy was brought 60 miles to Atlanta to the ophthalmologist, who decided that the infection was so extensive and so virulent that nothing radical should be done at that time. The child had very little increase of temperature, but was in intense pain, crying constantly.

He was given a total of six fever treatments of approximately one hour each, with a maximum temperature of 104.8 F. (oral). After the first treatment there was definite improvement in the appearance of the eye and subsidence of pain. Complete remission of the infection followed, and the ophthalmologist was able successfully to perform enucleation. This case, aside from the dramatic relief, was interesting to us in that the child

took his treatments with much less apparent discomfort and achieved his temperature maximum in less time than adults usually do.

A number of other cases of non-specific inflammation of the eye have shown equally good results.

CASE 5.—L. D. N., male, aged 45, on three different occasions had intense acute sacroiliac pain in the same joint following an unusual strain. In each instance, one fever treatment gave him complete relief immediately, and no other measure proved necessary.

We have had several other patients similarly affected and relieved. Some of our arthritis patients, even those with hypertrophic arthritis, who are being treated medically sometimes have acute exacerbations of pain though generally are comfortable. A single session of moderate fever has relieved the pain in virtually all of these upsets, so that the patient could continue his daily activity, which he could not do otherwise.

CASE 6.—Mrs. E. W., aged 35 years, suffered from sacroiliac pain for about three years and was in bed for one year. There were a number of other complaints, which responded to medical care. Seventeen fever treatments of one hour each at a maximum temperature of 103.8 (oral) relieved the sacroiliac pain, which has not recurred to date, about six years after the termination of the courses.

A number of patients with gonococcic arthritis of various duration and intensity were given relief when innumerable other measures were of little or no help. This affection is sufficiently extensive to make fever therapy available for all classes in any city.

We have seen many patients with various forms of peripheral neuritis, and have been able to give prompt relief to a large percentage of these.

CASE 7.—A rather unexpected situation developed in patient L. B., male, aged 65 years, who had a responsible and exacting government position. Among other ailments he was annoyed by a constant tinnitus, and this made him highly irritable and nervous. He was given a fever treatment as part of our asthma experiment, and later he noticed that he was free of the tinnitus for some time. Thereafter, whenever the tinnitus recurred, he returned for another mild treatment, and thus was able to control the disturbance and also his temper. Some other cases of tinnitus have been relieved since this first one, but no follow-up has been made.

Comment

There is reason to believe that some diseases are amenable to treatments of comparatively short duration and at moderately increased temperature. These include some forms of arthritis, certain eye diseases, acute rheumatic fever, neuritis, and affections that require a combination of moderate fever therapy with appropriate chemotherapy or other measures. It is clear however, that further research along this line should be of increasing value.

It is impossible to outline the future possibilities of a method which has advanced so rapidly in ten or twelve years, both in technic and clinical results. The fact that with proper management it can be rendered clinically safe opens a wide field for research.

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(*Concluded on page 752*)

INFRA-RED HEATING OVER TAPED SURFACES *

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It is frequently necessary to apply some form of heat over a part that has been strapped with adhesive tape. By the technic to be described it is possible to attain a definite increase in surface temperature when using luminous or non-luminous infra-red radiation over the taped part. The term luminous infra-red radiation refers to the source being employed, i.e., a tungsten filament bulb. The term non-luminous infra-red radiation refers to the resistance coil type of infra-red generator.

Other forms of heating such as high frequency currents, hot water, and melted paraffin do not lend themselves to cases of this type. With high frequency currents there is accumulation of perspiration beneath the adhesive tape resulting in the formation of areas of greater current concentration, and burns frequently result. Hot water and melted paraffin, even when used on waterproof adhesive tape, cause the tape to loosen up so that it no longer gives the desired support to the injured part. Infra-red radiation, then, remains the only feasible form of heat.

The problem as to the most efficient source of infra-red has been under investigation by many workers for at least a decade (Sonne, Anderson, Oppel and Hardy, and others). The last named investigators state that:

> White skin reflects about 35 per cent of the visible, 20 per cent of the penetrating infra-red, and practically none of the non-penetrating infra-red radiation -- the non-penetrating infra-red radiation is not reflected and is completely absorbed at the skin surface.

It is apparent from this reference that while 20 per cent of the penetrating (luminous) infra-red radiation is reflected from the surface of white skin, non-penetrating (non-luminous) infra-red radiation — though not reflected — still is completely absorbed at the skin surface. The significance of this observation seems to be that despite the 20 per cent reflection of the penetrating infra-red radiation, the remaining energy is not completely absorbed at the skin surface and therefore is available for heating the deeper layers of the skin and perhaps also the subcutaneous area. If white adhesive tape is placed on the skin, the amount of radiant energy reflected will be greater than for skin alone; therefore, there will be less energy available for heating of the underlying tissues. This is more marked for the penetrating than for the non-penetrating infra-red radiation, because the reflection of the latter is much less in both conditions.

It is a well known fact that a dark surface absorbs more radiant energy than does a white surface; with this thought in mind we decided to try various methods of blackening the surface of adhesive tape and determine whether by this means we might increase the amount of heat the patient would receive. The following experiment was devised:

In a ¾ inch board six by eight inches in size, two ⅝ inch holes, four inches apart, were drilled to a depth of three inches from its upper edge. For the first series of experiments two mercury thermometers were placed on the surface of the board and these in turn were covered by one thickness of adhesive tape. Readings were made under a source of infra-red

* From the Department of Radiology and Physical Therapy State of Wisconsin General Hospital, Madison.

* Read Before the Eighteenth Annual Meeting and Scientific Session of the American Academy of Physical Medicine, Richmond, Virginia, April 26, 1940.

at a distance of 52 cm. from the source to the surface. Readings were taken every five minutes for twenty minute periods. The following order was used in each case:

a) Both surfaces white.
b) Black cloth over one side, white cloth over the other.
c) One side of adhesive tape surface blackened with stove polish.

Two sets of readings were made for each division. Two different sources of infra-red radiation were compared; one was a 1000 watt luminous tungsten filament lamp with reflector, the other was a 600 watt non-luminous infra-red generator (Zoalite) with reflector.

The series of tests were repeated as above outlined for both sources with the exception that the thermometers were inserted into the holes and thus were separated from the surface of the board by ¼ inch thickness of adhesive tape.

The results of these tests are summarized in tables 1 and 2 and represented graphically in figures 1 and 2. Inasmuch as the readings under the white adhesive tape and those under the white cloth covered adhesive tape were almost identical they have been considered under one heading in both tables and graphs. The same holds for the black adhesive and the black cloth covered adhesive tapes.

TABLE 1. — *Surface Temperature in Wood Block Test.*

A) White Tape and White Cloth — Average of 8 readings			B) Black Tape and Black Cloth — Average of 4 readings		
	Luminous	Non-Luminous		Luminous	Non-Luminous
Start	28.0	28.0	Start	28.0	28.0
5	34.6	40.6	5	41.6	41.0
10	38.0	52.4	10	47.2	53.2
15	40.1	57.8	15	50.6	59.9
20	41.7	60.4	20	53.2	63.2

TABLE 2. — *Inside Temperature in Wood Block Test (Depth ¼").*

A) White Tape and White Cloth — Average of 8 readings			B) Black Tape and Black Cloth — Average of 4 readings		
	Luminous	Non-Luminous		Luminous	Non-Luminous
Start	28.0	28.0	Start	28.0	28.0
5	29.6	31.1	5	32.4	32.2
10	32.1	37.1	10	37.9	39.3
15	34.3	42.6	15	42.5	46.1
20	36.3	46.9	20	45.8	51.4

It is evident from an inspection of table 1 and figure 1 that the surface temperatures under blackened adhesive tape were much higher than under the white when the luminous source of infra-red was used. There is, however, no significant difference in surface temperatures between the blackened and white tape when the non-luminous source of infra-red was used. Also it is to be noted that the non-luminous source, although of lower wattage, produced markedly higher temperatures than the luminous source of infra-red radiation.

Inspection of table 2 and figure 2, again demonstrates the greater heating under blackened adhesive tape even at a depth of one-quarter inch in the board. As in the preceding table and graph, the differences are greater where the luminous source of infra-red radiation is used. It should be noted in this case that the difference in temperature between the blackened and white adhesive tape under the non-luminous source is of significant proportions at the fifteen and twenty minute readings.

Experiments on the wood block are not directly applicable to the human skin because the cooling effect of the blood stream is absent in the former.

Therefore another series of tests was run to measure the surface temperature of the skin under one thickness of adhesive tape. The experiment was quite simple:

Adhesive tape was strapped on the back. Next to the skin under one thickness we placed the bulbs of two mercury (centigrade) thermometers, locating them bilaterally over the points of the scapulae. On one side we painted the tape black, or in some cases a dull black cloth was laid over one side; in all cases the other side was left white. Where cloth was used to blacken one side, we placed a white cloth over the white portion lest the dead-air space under the black cloth give rise to an additional increase in temperature over the white side; this was found to be an unnecessary precaution. The source of infra-red radiation for the first series was the lamp using a 1000 watt bulb and reflector. The lamp was placed in a mid-position so that both sides would receive equal intensities. Readings were made every five minutes; the distance from the lamp filament to the skin surface was kept constant at 52 centimeters.

In the second series the technic was the same as described except for the source of infra-red. In this series we used the non-luminous 600 watt resistance coil with reflector.

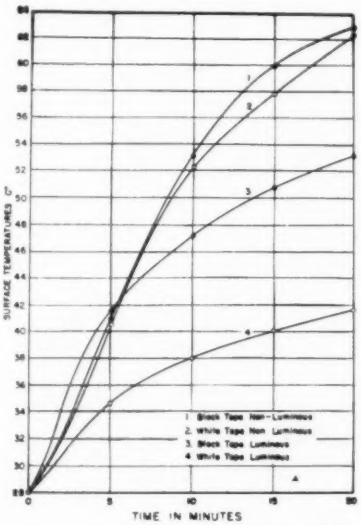

Fig. 1. — See table 1 and text for explanation.

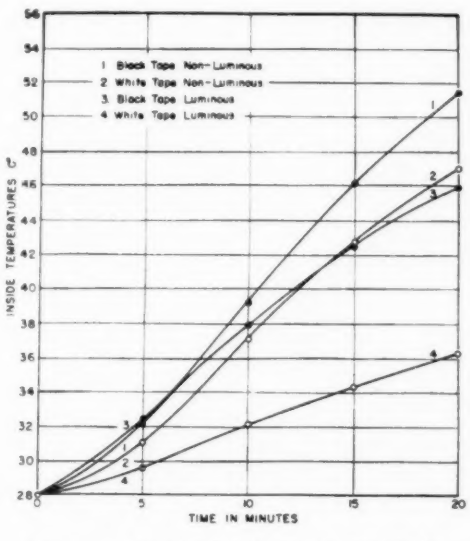

Fig. 2. — See table 2 and text for explanation.

The results of the first series are shown in table 3 and are presented graphically in figure 3. The data give the average for six tests.

TABLE 3. — *Luminous Source of Infra-Red Radiation: Average of Six Readings.*

Time	Black Tape	White Tape	Difference
Start	33.3 C.	33.5 C.	—0.2 C.
5′	41.6 C.	36.3 C.	+5.3 C.
10′	43.5 C.	38.0 C.	+5.5 C.
15′	43.8 C.	38.9 C.	+4.9 C.
20′	44.1 C.	39.6 C.	+4.5 C.

See figure 3.

In this series it is evident that the rate of increase in temperature under the black adhesive tape is more rapid than that under the white, and the final temperatures attained at each reading are higher under the black than under the white adhesive tape. The fourth column shows the difference in temperatures between the black and the white at each five minute interval. No separate readings for the black cloth — white cloth tests are shown, as it was found that that method gave almost identical results with the painting method of blackening the tape. Two of the six tests, the average figures of which are given, were run using cloth over the tape.

The results of the second series are shown in table 4 and are presented graphically in figure 4. The data give the average for three tests.

TABLE 4. — *Non-Luminous Source of Infra-Red Radiation: Average of Three Readings.*

Time	Black Tape	White Tape	Difference
Start	31.2 C.	33.0 C.	—1.8 C.
5′	42.6 C.	41.1 C.	+1.5 C.
10′	44.0 C.	42.5 C.	+1.5 C.
15′	44.1 C.	42.2 C.	+1.9 C.
20′	44.0 C.	42.5 C.	+1.5 C.

See figure 4.

In this series it is evident that the rate of increase in temperature under the black adhesive tape is not much more rapid than under the white. However, it is to be noted that there was a consistently higher temperature under the black tape from the first five minutes on through. The lower starting temperature on the black side is due to the fact that two of the three tests were made immediately after painting the tape with black stove polish

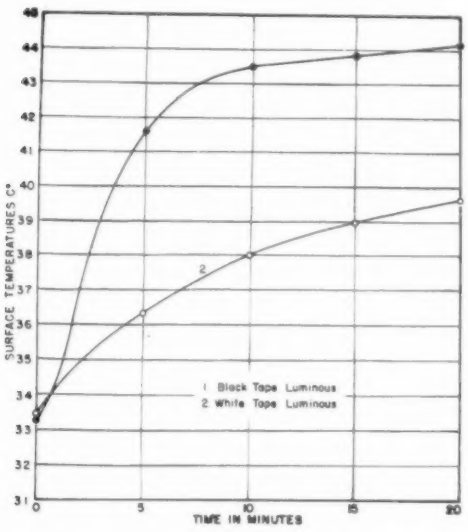

Fig. 3. — See table 3 and text for explanation.

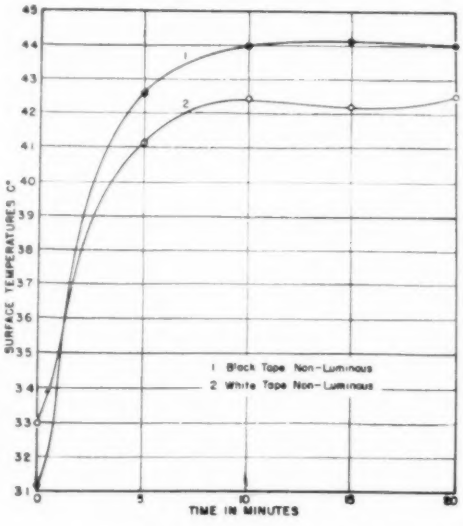

Fig. 4. — See table 4 and text for explanation.

and the evaporation of the benzene solvent had a marked cooling effect on the part. The fourth column in table 4 indicates that the differences in temperature under black and under white tape where the non-luminous source of infra-red radiation is used are not nearly as great as with the luminous source. This, I believe, substantiates the claim of Oppel and Hardy that the radiant energy from the non-luminous source is completely absorbed at the surface. A comparison of columns two in both tables is a further substantiation of this claim; it will be noted that the 1,000 watt luminous source did not equal the surface temperatures produced by the 600 watt non-luminous source until the last (20 minute) reading.

A comparison of columns three in tables 3 and 4 shows an even more striking example of the surface heating abilities of the two sources. Here, it will be seen, the luminous source never produced a skin surface temperature as great as the non-luminous.

It must be borne in mind that the temperature measurements in these tests were all made at the skin surface, the thermometer bulbs being covered by one thickness of adhesive tape. Therefore, we have no data regard-

ing the amount of heat reaching the subcutaneous tissue and hence we are not justified in reaching any conclusion as to which source of infra-red radiation is the most efficient for this purpose. In the tests where the thermometers were placed inside the board we still do not have a valid basis for comparison with heating in the subcutaneous areas since, as has already been pointed out, the cooling effect of the blood stream is absent in the wood block tests. That this factor is of real importance is well shown by comparing the highest temperatures attained in the several tests (tables 1, 3, 4). Laurens and Foster emphasize this point stating that:

> The effect of radiant energy on surface and subcutaneous temperatures is similar to but not identical with that seen in artificial homogeneous media, such as an agar jelly plate. The difference is due to the heat-distributing function of the blood.

It is clear, however, that higher surface temperatures are attained where the surface of the tape is blackened regardless of the source of infra-red radiation used.

The thermometers were checked against each other in boiling water and again at the temperature of melting ice. The variation between the two was but 0.1 C. at either extreme. For our purposes this was not a significant difference. It is possible that the temperatures shown in the tables may be slightly in error as to the absolute level, but this error would be constant so that the comparative temperatures are valid.

The actual blackening of the adhesive tape presented some difficulties. India ink was not suitable for waterproof adhesive tape and was only partially satisfactory for the ordinary adhesive tape. Black stove polish, because it is in a benzene solution, was quite suitable for blackening the tape, but when dry it rubs off on clothing. A large roll of black-backed adhesive tape, used commercially for masking, was obtained and has proved to be satisfactory in the experiments. This substance seems to be too light in weight to be useful for supportive strapping. Using dull black cloth over adhesive tape appears to be about as simple and effective a means of obtaining a black surface as there is now available. In the case of a strapped ankle, one could use a black cotton stocking over the adhesive tape.

Summary and Conclusions

1. Higher skin surface temperatures are attained in areas strapped with adhesive tape where the surface is blackened regardless of the source of infra-red radiation used.

2. Differences in surface temperatures are greater between the black and white adhesive tape when the source of infra-red radiation is luminous.

3. Means have been discussed for blackening adhesive tape.

4. It would seem that there might be a field of usefulness for black-backed adhesive tape for strapping a part over which the application of heat is desirable.

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AUTHOR'S NOTE: I wish to thank the Johnson and Johnson Company, New Brunswick, New Jersey, for their cooperation in furnishing the black-backed adhesive tape.

RHYTHM OF TUMOR GROWTH AND RECESSION *

MILTON FRIEDMAN, M.D.

NEW YORK

Fractional and protracted irradiation increases the difference in radiosensitivity between normal and cancer cells. This is accomplished in two ways: by a more efficient destruction of the tumor cells, and by a progressively improved capacity of the normal cells to withstand radiation effects. It is of interest to examine these phenomena of destruction and recovery in detail.

For a direct destructive effect upon the cell, Regaud's basic experiment and its subsequent elaborations indicate that cells have specific periods of increased radiosensitivity during the mitotic and premitotic periods. It has been shown that fractional and protracted irradiations increase the destructive effect by permitting their influence upon a greater number of cells during their radiosensitive period. However, there are still many hiatuses in the logic and practice of this thesis, suggesting that all the phenomena of radiation destruction are not yet fully understood. For instance Canti and Spear, and Love state that a cell is most radiosensitive several hours prior to the onset of mitosis when the radiation effect has been sublethal, i. e., just enough to inhibit mitosis. However, as Lea points out:

> A given dose of radiation produces the same physical and chemical changes in a cell due to divide an hour hence as in one due to divide five hours hence, yet, on account of the times available for recovery being different, the one cell finds itself unable to commence division at the proper time, while the other cell enters mitosis entirely according to program. Thus it is quite true to say that if one wishes to demonstrate a visible effect of radiation upon a cell, one is most likely to be successful if one chooses to irradiate it shortly before it is due to enter mitosis, but it is hardly correct to say that a cell has a period of special sensitivity shortly before it is due to divide.

Irradiation in sublethal doses retards mitosis, but when the inhibiting effect wears off, there is a compensatory increase in this cell phenomenon, under specific conditions. Thus the effect of such experimental sublethal doses of radiation on mitosis is a postponement as well as an inhibition, and its true nature is still only partially understood.

When irradiated squamous cell carcinoma is examined microscopically, the prekeratinized cells of the polyhedral cell layer often show evidence of destruction earlier than the actively dividing basal cells of the germinal layer. Thus the chemically labile cells (those about to undergo keratinization) appear to be as susceptible to radiation as the biologically labile cells (those undergoing active cell division).

The direct destructive effect on tumor cells does not manifest itself exclusively by retardation or inhibition of mitosis. Only the actively dividing basal cells are so influenced. The more differentiated cells are destroyed in several ways: by a rapid disintegration of the cell; or by a rapid maturation, keratinization and eventual desquamation of the now senile cell. This latter phenomenon may be further observed grossly after the first week of treatment when a pearly white, almost leukoplakic membrane forms on the gums, buccal mucosa and hard palate. This membrane is composed of desquamated parakeratinized cells which have been rapidly matured by the ir-

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* Read at the Third International Cancer Congress, Atlantic City, September, 1939.

radiation. It does not usually form on the tonsillar pillars, soft palate and uvula, because their mucous membranes do not have such a marked tendency toward keratinization. It is therefore likely, in a tumor composed of squamous cells in various stages of development, that some of the irradiated mature epidermal cells undergo rapid maturation, keratinization and desquamation, while the irradiated mucous membrane type of cell is destroyed in other ways. This rapid acute maturation is morphologically similar to that of the portion of a tumor which has withstood a course of radiation bombardment. The fact that it can occur within a few days suggests that the maturation is due to a direct effect upon the cell rather than to a secondary one of recovery which is observed much later.

Daily Exposure Time. — It has been stated that a low dosage rate with prolonged exposure time enhances the radiation effect by affecting a larger proportion of cells while they are undergoing mitosis. Coutard exposes his patients for several hours a day. Some therapeutists give one-half the treatment in the morning and the other half in the afternoon. This prolonged exposure is beneficial, but to a lesser degree than is generally accepted and even then for only a certain number of days.

It has been shown by others and myself that, with a single exposure producing a mild erythema, a low dosage rate is less effective than a high one (comparing 200 K. V. x-rays at 10 r min. with 50 r/min.). When this type of experiment is extended so that the erythema effect is produced with fractional doses over a period of four days (Quimby), the low dosage rate (375 mc. hr. continuously applied for 96 hrs.) produces the same effect as the high dosage rate (three doses of 115 mc. hr. each given in the 1st, 48th, and 96th hour). However, when the comparison is extended for approximately twenty-one days and the daily exposure times are one hour and twenty-four hours respectively, the effect becomes reversed, in that the continuous, uninterrupted irradiation is 20 per cent more effective than fractionated irradiation with the same daily dose given in one hour. Many authors have predicted that continuous irradiation, such as supplied with small radium packs which would irradiate all cells during several periods of mitosis, would be the most effective method. Since according to Regaud a cell in mitosis is approximately eight times as radiosensitive as in a mature form, it was assumed that such continuous irradiation would be several times more effective than fractionated doses. With the latter technic the tumor cells could recuperate and possibly proliferate for twenty-two or twenty-three hours each day. We have found that continuous 24-hour-a-day irradiation provides only a 20 per cent increased effectiveness as far as skin and mucosal reactions are concerned, and only a slight, inconclusive clinical superiority. This indicates that the clinical significance of the law of Bergonié and Tribondeau is very small, and certainly much less than experimental evidence would indicate.

General Destructive Phenomena

The general phenomena of destructive effects were studied by analyzing the epithelitis and epidermitis curves of over 200 cases of carcinomas of the upper respiratory tract treated with a standard technic. A daily dose of 200 r (with b. s.) was given to each of two lateral neck portals through a 10 by 15 cm. portal. The total dose was 8,000 r given in four weeks.

During the first four weeks of treatment (the destructive phase), destructive effects dominate the picture. These are a function of and dependent on external factors, such as ray quality, dosage rate, size of daily dose,

and time spacing of treatments. When the dose is overwhelmingly destructive, producing severe second degree reactions of the skin and mucosa, these tend to be fairly constant during the course of the destructive phase. This constancy of severe reactions is so dominant as to be only slightly influenced by ray quality (within certain limits), and exposure time. When the treatments have ceased, and the reactions commence to subside, usually during the fifth or sixth weeks, the recovery or reparative processes dominate the picture. During this phase, these processes mostly depend on the reaction of the organism and exhibit a very wide range of individual variation in response to similar amounts of irradiation. The variability of recovery processes, especially in comparison with the destructive ones is one of the dominating factors in protracted, fractionated irradiation. The character and evaluation of these reactions are important for proper irradiation of a particular tumor in a particular tumor bed.

The changes during the destructive phase may be said to be influenced to some extent also by the recovery processes. The intensity of the resultant effect is a function of the size of the dose and its accompanying influence on recovery. In studying the outcome of ray quality on the destructive phase by comparing 200 K. V. x-rays filtered with ½ and 2 mm. copper, it was found that the 2 mm. copper filtered x-rays produced epithelitis and epidermitis reactions which began later and were less severe than those of the ½ mm. copper filtered x-rays. A possible explanation for this is that the shorter wavelength is biologically less effective than the longer roentgen ray. It therefore inhibits recovery less than an equal amount of longer wavelength x-rays, and thus permits the more active recovery processes to retard and depress the reactions of the harder radiation, as will be shown below.

In a previous study of protracted fractionated irradiation, I compared the reactions produced by x-rays with those produced with gamma rays from a 5 gram radium pack. The gamma rays were given in daily doses of the same exposure time as x-rays, and with unit doses of a size to produce similar reactions, i. e., a daily dose of 2500 mg. hr. to each of two portals. It was found that the gamma ray reaction curves occurred at approximately the same time as those of the x-ray. This suggested the conclusion that protracted, fractionated irradiation, producing severe destructive effects (second degree erythema), completely eradicated ray quality differential effects; and that the observed difference in effect between ½ mm. and 2 mm. copper filtered x-rays was only an experimental error. However, there are two facts which seem to contradict this and still permit consideration of a ray quality differential effect. First, our deduction, based on the comparison of fractionated gamma rays with x-rays, was partly erroneous. The two qualities of x-rays were administered in equal daily calibrated doses. The gamma ray daily dose on the other hand was empirically ascertained as the quantity necessary to produce a similar severe biologic reaction and was not physically equal to the x-ray daily dose. Consequently, as would be expected when severe destructive doses are administered, the reactions were similar. To this should be added the fact that Stone, in his clinical experiment comparing the skin reactions of 200 K. V. with 1,000 K. V. x-rays, found a differential effect in that the shorter wavelength was less effective biologically.

In another group of cases, instead of giving a daily dose of 200 r (measured with scattering) to each of two lateral neck portals, one of 400 r was given daily to only one alternate portal. The resultant epithelitis curves were of the same range with both technics. Thus, in a busy clinic, when

the exposure time and multiplicity of daily portals is not of great importance in a particular case, only one setting need be made.

Recovery Phenomena

As previously shown, one of the biologic effects of irradiation on keratinizing epithelium and on the prekeratinized cells of a squamous cell cancer is to produce a rapid, acute maturation of the cells in the direction of parakeratinization and eventual desquamation or else mummification of the cell. There is now evidence that under small daily fractionated doses of irradiation, after the more radiosensitive cells have been destroyed, the residual tumor histologically becomes more mature. There is observed a greater proportion of keratinized cells as well as epithelial pearls. This histologic maturity probably accounts for the increased physiologic maturity in the form of increased radioresistance of the residual tumor cells during the healing phase. Occasionally such cells may become so indifferent to irradiation as to resume proliferation while being irradiated during the healing phase.

In order to study the recovery from mild destructive effects a group of cases was treated with one-half the usual daily dose and the daily treatments extended unduly up to 3½ months. This small daily dose did not produce overwhelming destructive results, and permitted the recovery processes considerably to influence the reactions (epithelitis and epidermitis). As a consequence, instead of being somewhat constant, the reactions exhibited a wide range of individual variation, were late in onset, and mild in degree. It might be argued that the late onset and mildness of the reactions were due exclusively to the small daily dose and hence its slow cumulation of destruction. However, in the group of patients who received the larger average daily therapeutic dose (i. e., 2 x 200 r, and the like), a certain number were markedly hyposuspectible or radioimmune, and their reactions exhibited the characteristics of a strong healing influence; namely, wide range of individual variation, a tardy onset, and a mild intensity. The usually employed quality of fractional irradiation has little influence upon the healing process. The size of the daily dose and the total dose, however, are important. If the destructive effects are overwhelming, healing processes are inhibited. When the daily dose employed is 200 r (with b. s.) to each of two lateral neck portals, the destructive effects are cumulative so that in 90 per cent of the cases the reactions become progressively more intense. However, in the other 10 per cent of these cases, the healing processes cumulate with such acceleration as to cause the reactions to heal in spite of continued irradiation. This daily dose produces therefore a maximum threshold effect. When one-half the above daily dose is employed, namely, 100 r to each of two portals, about 95 per cent of the reactions heal during irradiation, and 5 per cent become completely destructive. This smaller dose produces a minimum threshold effect. The critical intensity is probably close to the larger daily dose.

When daily fractionated irradiation is unduly extended for two or three months, it is observed that destructive and recovery effects are not constant and their interaction produces cyclic phenomena. These are observed either when the daily dose is small and does not produce overwhelming destruction, or when the radioimmunity is high and large daily doses produce subintensive effects. During the first 28 to 35 days of treatment the effect of the daily fractionated doses cumulates and the reactions become more intense. Each destructive effect evokes a companion healing action, which is also cumulative. The latter starts slowly, increases in momentum, and then

changes from a potential to a kinetic force, thus initiating the healing phase, during which the reactions abate while treatment is being given. After an additional period of 28 to 42 days, the healing may wear off and a new cycle of destructive effects initiated.

This interpolation of a healing process which starts slowly and then increases in magnitude, is not inconsistent with the recovery process described by Reisner, and Quimby and MacComb. Their magnitude of recovery is greatest on the first day and then becomes progressively smaller until it reaches a stationary level. This is probably due to the fact that on the first day, it is unopposed by any residual destructive effect of a previous treatment. This early recovery phenomenon appears to be a passive recuperative one, occurring as a function of the size of the radiation dose itself, while the healing process described above is less a recuperative or recovery one, and more of a true, active one, accompanied by histologic maturation of incompletely developed residual cells, together with an increased physiologic capacity of these matured cells to defend themselves against radiation bombardment.

Therapeutic Application

In fractional irradiation it is probably important to avoid any break in the continuity of treatments. If treatments are missed during the first few weeks of the destructive phase, the recovery processes will be permitted to increase in strength. This is beneficial in protecting the skin, but it may be harmful in that the tumor may be permitted to recover and mature, thereby becoming more radioresistant. Furthermore, the course of treatments may be prolonged into the healing phase, at which time radiation is much less effective. Frequently, treatments are interrupted about the eighteenth day to permit severe reactions to subside. They are then resumed in two weeks. Such treatments are given usually when the healing processes are at their height, and are not very effective.

Practical Applications. — These general principles can be helpfully utilized by carefully observing the behavior of the tumor and the reactions during and after treatment.

Individual variation in response to irradiation, which is slight to moderate during the destructive phase, becomes enormous during the healing phase. During the destructive phase 25 per cent of the patients exhibit unusual reactions of hypo- or hypersusceptibility, and our ability to detect these aberrations early in the course will assist materially in the conduct of the treatment. For example, we have found that if epithelitis has not yet appeared by the fifteenth day, there will be no primary shrinkage of a tumor. In other words, such a patient's radioimmunity of his mucosa is reflected in the growth. Under such circumstances, the daily dose can be considerably increased after the fifteenth day and, where possible, interstitial irradiation given early. Another example: If the epidermitis should commence on the twelfth day or earlier, recurrence may be anticipated. This is due to the circumstance that the patient's marked hypersusceptibility to radiation prevents the administration of an effective total dose. In such a case other methods of irradiation should be employed as a supplement.

Examination of the rate of shrinkage of a tumor is of some help in estimating the eventual effect of fractionated external irradiation. If a tumor has shrunken 50 per cent in size by the sixteenth day, it is probable that it will be destroyed by external radiation alone. For many reasons (discussed in a previous publication) this observation is not as accurate as the others and is only confirmatory. A biopsy taken on that day, however, may be help-

ful. It will show in a favorably responding tumor very few residual normal tumor cells, considerable necrosis and disintegration of the neoplasm.

After the treatment has been completed and the reactions have subsided, the probability of recurrence can be estimated by a re-examination of the reaction curves. If the tumor apparently has disappeared completely, but a second degree epithelitis and epidermitis has not been attained, there is a strong probability of recurrence. An occasional patient can be cured without having sustained second degree reactions, but his lesion usually is a small one. At any event it should be held suspect or treated immediately with a small dose of interstitial irradiation.

As previously shown a small daily dose is inefficient in that it permits the recovery processes to acquire too great an importance, and it projects treatment into the healing phase. In the treatment of upper respiratory tract tumors, it is common practice not to exceed a total daily skin dose of 400 r (measured with scattering). However, when irradiating carcinoma of the breast and cervix, the daily total skin dose should be increased. Otherwise the multiplicity of portals in treating a breast preoperatively, and the greater depth of the tumor in a cervix carcinoma result in an inefficiently low daily dose and cumulative total dose. Furthermore, in the cervix particularly, subsequent radium will be directed at a tumor which has been matured and rendered more radioresistant following preliminary x-ray therapy.

Conclusions

1. Cells undergoing parthenogenesis (i. e., physiologically labile cells) are unduly radiosensitive. The prekeratinized cells of the polyhedral cell layer of stratified squamous epithelium (i. e., chemically labile cells) are also in an unusually radiosensitive phase.

2. Radiation affects keratinizing epithelium by producing not only disintegration but also rapid acute maturation, parakeratinization and eventual desquamation.

3. During the course of irradiation the destructive and healing processes maintain continuous and active opposition. The one which happens to be dominant will endow the clinical picture with its specific characteristics. This dominance tends to alternate and to be cyclic.

4. Of all the factors enhancing radiation effect, fractionation is the most important. It is far more important than protraction, and ray quality (within certain therapeutic limits). Protraction of the daily exposure time, though important, does not improve the radiation effect as much as experimental evidence would indicate.

5. Cells, which were sublethally irradiated (whether because of a small daily dose, or because of marked radioresistance) become more mature histologically as well as physiologically.

6. Marked individual variation in response to fractionated irradiation is common. Such hyper- or hyposusceptibility of the skin and mucosa may be reflected in the tumor. These features may be usefully employed in guiding therapy.

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(Concluded on page 748)

SCIENCE, NEWS, COMMENTS

New York Physical Therapy Society

The New York Physical Therapy Society will hold its regular December meeting, Wednesday, December 4th, 1940, at 8:30 P.M., at the New York Academy of Medicine Building, Fifth Avenue at 103rd Street, New York, N. Y.

The following program is planned:

1. Scientific Session. — Electric Shock Therapy in Mental Disorders. Demonstration by Machine. — *Paul H. Hoch*, M.D. (by invitation).

Discussion opened by *S. Eugene Barrera*, M.D. (by invitation).

2. (a) The Need of Learning Relaxation — Description of Certain Cases Recently Referred. (b) Items Discovered by Draft Board Physicians — a Challenge to Physical Medicine and Physical Education — *Josephine L. Rathbone*, Ph.D. (by invitation).

General discussion. All physicians are welcomed.

II. Executive Session.

Insulin Changes Cancer Cell

Starvation treatment of wildly growing cancer cells that caused them to turn toward normalcy, accomplished in test tube experiments, was announced by Drs. Richard H. Steckel and John R. Murlin, University of Rochester, at the meeting of the Federation of American Societies for Experimental Biology in New Orleans.

This change from cell activity characteristic of cancer toward normal activity was made by starving the cancer of sugar through the use of insulin, the diabetes remedy.

"The experiments offer no proof that insulin will cure or prevent human cancer," the Rochester scientists stated in response to inquiry.

The results, however, seem to be an important advance in the chemical attack on cancer by which scientists have long hoped to conquer this great killer of mankind. Changing the diet on which cancer thrives brought about this hopeful effect.

Slices of cancer from a rabbit were grown in blood from another rabbit that had been thrown into insulin shock by huge doses of the diabetes remedy, such as are being used in insulin shock treatment of mental disease. This blood, as a result of the insulin treatment, is deficient in sugar. Its effect in reversing the cancer toward normal was explained by the Rochester scientists in the following exclusive statement:

"Unlike normal cells, tumor cells get their energy principally from fermentation of glucose to lactic acid instead of complete oxidation of the sugar. This was shown by Prof. Otto Warburg, German Nobel laureate, and associates as early as 1923. Many attempts have been made to restore normal metabolism and thereby 'burn out' the tumor. Prof. Warburg himself and many others used insulin on tumor-bearing animals, but with no clear indication of success.

"Recently this laboratory has undertaken the use of insulin in a different way, on the hypothesis that it should discourage the tumor's growth by: First, starving it of sugar for glycolysis and, second, promoting oxidation of sugar. The present experiments show merely that tumor slices placed in hypoglycemic (sugar deficient) serum have their oxidative metabolism markedly increased and the fermentation metabolism greatly diminished.

"Both are changes in the direction of the normal. The Brown-Pearce transplantable carcinoma of the rabbit was used and only young, vigorously growing tumors chosen. Slices from the same tumor were studied simultaneously in serum from the normal rabbit and from the same rabbit after being thrown into insulin shock. The effect on fermentation probably is due wholly to the lower blood (serum) sugar but the effect on oxidation may possibly be the result of a combination of factors. The experiments offer no proof that insulin will cure or prevent human cancer." — *Science News Letter.*

Metropolitan Medical Activities

Their nativity in nine different nations marked the American citizens attending the new season's first dinner-meeting of *New York's International Medical Club, at Hotel Delmonico*, November 15. An address was made by Colonel S. J. Kopetzky on the Army and Preparedness; also, by Captain W. S. Bainbridge, on the Navy in the first world war and in the present situation. The annual election resulted in the choice of Richard Kovács, M.D., as president, and in reelection of Edward Frankel, Jr., M.D., as secretary-treasurer.

"Irradiation in Dermatology," is the title of a paper by Anthony C. Cipollaro, M.D., that he will read on invitation before the Radiological Society of North America, meeting December 2-6, at Cleveland.

"Radiation Therapy of Brain Tumors," is the title of a paper by Ira I. Kaplan, M.D., that he will read December 3 before the annual meeting of the Radiological Society of North America in Cleveland. On Friday, December 6, at the same meeting he will give one of the Refresher Courses on the Radiation Therapy of Inflammatory Diseases.

ARCHIVES of PHYSICAL THERAPY
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.·. EDITORIALS .·.

YULETIDE HOPES AND GREETINGS

It would be self-delusion were one to observe the ancient custom of extending Yuletide and New Year's greetings to friends and neighbors in the spirit that has prevailed in the past. How can any one true to one's self pretend to or actually enjoy the festive spirit of Christmas and of the change of year when almost the entire world is in the throes of misery and tragedy? How can we in America think only of ourselves while innocent men, women and children, born free, are daily facing mutilation or worse? How can Christianity sing Christmas carols with a happy heart when a number of men who have arrogated to themselves great political and physical power are bent on destroying the very spiritual life of modern civilization? When freedom of Divine worship is taken from the faithful, when teachers in more than one land are forced to inculcate in the minds and hearts of their charges the doctrine of armed might as the highest goal, those that have been spared such a fate cannot experience the joy of the season without it being dampened by compassion for that part of humanity which is and will be enslaved for some time to come.

Under these sad actualities the present season must awaken in the hearts of true Americans a sense of gratitude rather than of gladness. Gratitude that we are living under a flag which still is and let us hope always will be the emblem of human freedom. Gratitude for the fact that our schools and universities are not forced to preach war as the ultima Thule, but can continue in their proper mission for the benefit of mankind. Gratitude that in our land all men are equal before the law, and that books are not burned by educated hooligans because of the authors' creed, race or nationality. Gratitude that our Government is at one with the nation for the defense of our sovereignty and is preparing to defend our national and individual rights. And gratitude because our profession is still privileged to carry out its humane and ethical mission without interference and oppression.

We rejoice in all this, but with humility. Humility, because "peace and good will" is not all over the earth as it is with us, and because many of our fellow men on other continents are condemned to endure spiritual and physical enslavement.

The Yuletide season, then, should be a period of sober reflection, of a renewal of our pledge to aid suffering humanity to the best of our ability, to be prepared and willing to overthrow brute force and to restore right, and above all to uphold our cherished American ideals.

In this sense we can whole-heartedly celebrate an American Christmas and New Year. And it is in this spirit that the officers of the Congress and the editorial staff of the ARCHIVES extend American greetings to our members, subscribers and advertisers. And these greetings are accompanied by our hopes and prayer that 1941 may bring the world a just peace and restore happiness to all mankind.

THE INDEX AND ITS IMPORT

With the primary purpose of the index of a completed volume in view, an effort has been made so to classify and reorganize the various titles published in THE ARCHIVES during 1940 that they can be easily found. As in the past the names of authors and contributors, the titles of subjects and those of books that have been reviewed are given as separate groups. News and personal items are not indexed partly for the purpose of economizing in space and partly because of their ephemeral interest.

Apart from this, the index is or should be an authentic indicator of the year's literary output. To those who make use of it, it must become clear that while this has not increased to an appreciable extent, we must look to the qualitative aspect in order to judge the merits of the year's manifold contributions. Any student of the subjects provided in the 1940 volume of this monthly publication will admit that they have brought material of positive value for everyday practice. While theoretical speculations and methodical research have found a place in the columns, especially those that have been judged to offer possibilities worthy of consideration, the majority of the contributions were held well within the domain of actual practice and its needs.

From a numerical point of view the reading matter assumed the size of a large monograph. When it is considered that even here in America not a few general and special medical journals have been forced to curtail the number of their pages so that the annual volumes have a homeopathic dimension in thickness, then it cannot escape the observant reader that this publication has maintained a size in keeping with the importance of the Congress it officially represents, and this in spite of certain economic restrictions imposed on our organization. This in turn clearly implies that in America at least physical medicine as a specialty is in a flourishing condition. When one considers that the present volume contains 80 original articles, countless discussions of a scientific nature of papers read before the last meeting of the Congress, no less than 152 abstracts, and 56 reviews of worth-while books, then there can be no thought of paucity of scientific endeavor in our particular field.

The question of abstracts gives rise to some serious thoughts. A glance at the list of American and foreign periodicals from which they have been culled in the past and this year will reveal a situation which merits full realization. The unfortunate political situation abroad has proved more than a damper on scientific publications of all sorts, but notably of physical medicine. Indeed, this discipline has as a result of political upheavals been well-nigh rendered nonexistent, at least in a literary sense. Today THE ARCHIVES is the periodical in the English language that gives all interested in physical therapy the fullest means of keeping abreast with its progress along clinical as well as experimental lines. The 1940 index also shows that it is not alone the physical therapeutist or the general practitioner who has a vital interest in our discipline. The surgeon, the internist, the neurologist, the ophthalmologist, the laryngologist, the urologist, in fact every medical specialist has realized the need for physical measures in each particular field, as is evidenced by the contributions emanating from various professional sources.

While an index as published at the conclusion of an annual volume is a convenience for future reference rather than a vital necessity, it is considered of sufficient importance and value to induce the editor to ask the readers to offer any suggestions toward its improvement in the years to come.

THE STUDENT'S LIBRARY

GOLDEN ANNIVERSARY 1890-1940. The Waverly Press. Baltimore, 1940.

This artistically prepared de luxe edition of the rise and development of the Waverly Press commemorates the fiftieth anniversary of the founding of this company and is of interest to the medical profession in America. It is the story of John H. Williams and Henry B. (Harry) Wilkins of Baltimore, and particularly the success story of Edward B. Passano who like one of Horatio Alger's heroes rose to the Presidency of this now renowned institution. This brochure proclaims in modest descriptions but beautiful format the golden anniversary of one of the country's leading publishing houses, and tells of its humble beginnings, its struggles, its fruition of ideals from dreams to actualities, which strengthen convictions that this land of ours is one of promise and fulfillment. It is the courageous and inspirational biography of an institution that began as a printing shop in the basement of Williams' home, conducted after school hours and during summer vacations in that dim period of fifty years ago. It tells how it prospered and how expanding activities required the extra finance brought in by the new partner Wilkins, some two years later, and how Mr. Passano entered this enterprise, grew into it and made of it the flourishing corporation it now is. Today this ultra-modern plant operates the Waverly Press and the Williams and Wilkins medical publications under an interlocking directorate that works for this dual organization. The comparative financial record of the first year (1890) and that of last year (1939) shows an increase of sales volume from 25,000 to one and one-half million dollars. Congratulations to the Waverly Press and the house of Williams and Wilkins, the warmest felicitation to its living genius, Edward B. Passano.

THE TREATMENT OF RHEUMATISM IN GENERAL PRACTICE. By *W. S. C. Copeman*, M.S., M.D., B.C.H. (Cantab.), F.R.C.P. (London). Physician-in-Charge, Department of Chronic Rheumatic Disease, West London Hospital, etc., etc. Third Edition. Cloth. Pp. 276. Price, $4.00. Baltimore: A William Wood Book. The Williams & Wilkins Company. 1939.

The popularity of this work is attested by the fact that within a relatively short period it passed through several editions. This being the latest presentation it may be interesting to point out that while the author makes no pretense of contributing a highly technical dissertation on this vast domain, he has nevertheless presented an informative review of the symptoms encountered in rheumatic disease and evaluated their management in that informal but lucid manner that comes only from one long experienced with its manifold problems. As perhaps expected, the book has been considerably revised and rewritten. The new material provides wider understanding on such subjects as gout and focal sepsis and offers a sharper orientation of such new and improved treatments as "serial plasters" in rheumatoid arthritis, which was first introduced by Swaim in America to provide rapid relief of pain in immobilized joints. It also evaluates the use of postural methods, the injection of novocain-saline for fibrositis, epidural injection in sciatica, wide field x-ray irradiation, estrogen compounds in menopausal arthritis, the administration of intravenous anesthesia such as sodium pentothal for manipulation of joints, gold salt therapy, and the like. Though the book is more designed for the general practitioner than the rheumatologist, both will find the reading of the 25 chapters highly informative and confirmatory of the most advanced views on the treatment of rheumatism. Every practical phase of this broad problem is touched upon with incisive detail and authoritative sweep. It discusses the therapeutic approach based on an experience that can include the pros and contras of medicinals, diet, vaccines and non-specifics, physical methods, manipulation, baths and colonic therapy, ultraviolet radiation and spas, limitations of such measures as osteopathy and other borderline practices. The last chapters dealing with prognosis and end results represent a clear, conservative and practical summary that could be accepted by the most critical student.

FM FREQUENCY MODULATION. By *John F. Rider*. Cloth. Pp. 136. Price, $1.00. New York: John F. Rider, Publisher, Inc. 1940.

This small volume is among the very first to discuss a revolutionary phase in commercial radio reception; namely, frequency modulation—the invention of Professor E. H. Armstrong. As is well known, up to recent times all commercial broadcasting stations regardless of their operating frequencies made use or are still employing waves designated as amplitude-modulation for transmission of their programs. The tomorrow of this branch of public service promises to be significantly and radically changed with the introduction of FM, so much so that it will no longer be an academic curiosity but a problem whose elucidation will be demanded by both the lay public and the scientific individual interested for one or another reason in the transmission and reception of radio energy. In the latter group belongs that increasing group of physicians employing transmission of high frequency current for therapeutic purpose. Indeed, when thinking in terms of the present mercurial era one cannot discuss FM in terms of future tenses. Frequency modulation is already here as indicated by the number of broadcasting stations throughout the country that have already installed secondary transmitters

operating upon experimental licenses and sending out such frequency modulated waves for public reception. Accordingly, this book is of timely interest because it offers a critical and relatively non-technical exposition to meet the demand for information concerning the general theory underlying the operation of such receivers as well as the problem of their maintenance. The discussion embraces an evaluation of the general differences between FM and AM systems. It explains and illustrates by charts what for instance happens at the transmitter and receiver end when this form of radio wave energy is employed. Chapters are devoted to the explanation of how transmission signals are propagated and their range; how FM receiving antennas are set up for adequate signal pickup, and how one may understand the practical servicing of such receivers. A comprehensive bibliography is appended which should be informative reading for those especially interested in this field of radio engineering. The name of Rider as author is a guarantee that the subject has been presented with that same clarity and authority that have made his past publications in great demand.

DER RHEUMATISMUS UND DIE STREPTOMYKOTISCHE SYMBIOSE. PATHOLOGIE UND THERAPIE (Rheumatic Disease and Streptomycotic Symbiosis. Pathology and Therapy.) By Dr. med. *Wolfgang H. Veil*, ordinary public Professor of Internal Medicine of the University of Jena and Director of the Medical University Clinic. Paper or Cloth. Pp. 733. With 173 illustrations, 2 colored charts and 5 charts. Price, Rm. 70, resp. 73, less 25 per cent for foreign lands. Stuttgart: Ferdinand Enke Verlag. 1939.

When one considers the environmental influences under which the eminent clinician has been laboring during the past years, one cannot but be greatly impressed by the unmistakable proof he provides that true science breaks all chains and cannot be suppressed. Both the academically trained profession, and the cultists have come in for sharp criticism because precisely in the disease-processes grouped as "rheumatism" diagnoses are inadequate and scientific approach to many of their obscure problems is routinistic instead of philosophic and resting on a sound bio-pathologic basis. Rheumatism has been considered as banal, because bacteriologic and chemical investigations have proved negative. It is only recently that the import of the diverse forms of acute and chronic rheumatism has been appreciated. In the main the title of this unusual monograph shows the basic concept of streptomycosis as the underlying cause of the affections under consideration, but Veil goes farther than that in presenting associated conditions, notably nephroses and heart diseases, as being due to focal and other infections. Nor should the book be regarded as a merely extensive exposition of theories, for the author clearly betrays a vast clinical experience through the detailed description of actual patients treated and carefully studied to which he has applied the entire scientific armamentarium plus clear, logical thinking. As a result, even acute inflammatory processes of the articulations, while requiring topical treatment for symptomatic relief, are merely secondary phases. Not only focal infections but certain constitutional factors come into play. He demands revision of the concept of "chilling," such as advanced by Pemberton and others. Therapeutic failures are ascribable to the confusion that still exists with regard to the definition and proper grouping of rheumatic and associated processes. The text proper opens with a critical historical review, in which Veil sounds a note of warning to return to Hippocratic methods of research and thinking. After reviewing the prevalent concepts, most of them improper, about the nature of rheumatism, the book covers every aspect of this problem. His more than hundred case reports portray actual conditions, and they are perhaps even more instructive than the critical comments, to say nothing of splendid x-ray and other illustrations elucidating the pathologic findings. One cannot do justice to the book since titles cannot be enumerated let alone discussed, and it must therefore suffice to point out that the book advocates the acceptance of rheumatic disease as a clinical entity in which streptomycosis intimately associated with the life of the human organism plays the most important role. The author has accomplished a great task, the study of which will prove a veritable fountain of knowledge to all interested in the concerned problems.

Rhythm of Tumor Growth and Recession — Friedman

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INTERNATIONAL ABSTRACTS

Occupational Therapy for Sick Children. Elsa Neustadt.

Hospitals **13**:103 (Dec.) 1939.

The ideal would be to set up a workshop in every children's hospital. It should be a large room, light and sunny, with direct access to the garden. The children should be dressed in light-colored overalls, buttoning down the front. In this room everything should be of a size suitable for children; not only should the tables and chairs be small, light colored, and portable, but the fastenings on windows and doors, the taps, sills, and pictures should be within easy reach. There should be brooms and buckets available. The room and its furnishings should be so charming that the children themselves will enjoy keeping it clean.

Children in hospitals are often very naughty and disobedient. They are spoiled by misguided love or pity of nurses and of relatives on visiting days. The child tends to become more and more egotistical; taking himself too seriously and thinking of nothing but his ailments, he may thus come to tyrannize over his whole circle. Educative measures which prevent such happenings, even if they last only while the child is in the hospital, may play an important part throughout the whole course of his life.

A treatment that shows understanding and to which wise employment is added, will strengthen the child's will to health. Moreover he will be helped in his transition from the hospital to the everyday life outside. Obviously, the time spent in the hospital will leave its traces not only on the physical but also on the psychic life of the child. It will remain in his memory much more deeply than other periods of his life. So during this stay he must be exposed to impressions which will be both helpful in his own future and useful as an influence in the family circle. There is the further great advantage that the child's return to health will be hastened by suitable occupations which elate his spirit.

Experimental Hibernation of Metastatic Growths. Arkell M. Baughn.

J. A. M. A. **114**:2293 (June 8) 1940.

Six patients with hopeless metastatic carcinoma, ranging in age from 26 to 52 years were subjected to subcritical temperature, the lowest degree reached being 83.2 F. per rectum, the time spent under such an environment ranged from nine and a half to fifty-four and a half hours. Only the seriousness of our patients' condition accounted for the nine and a half hour hibernation. Basal metabolic rates were determined at the submerged temperature, the lowest being 84.2 F. rectal. The metabolic rate was lowered in every case in which the determination was made. Primary carcinoma of the breast with metastases in the bones was the diagnosis in four, and generalized carcinomatosis of the abdomen from primary carcinoma of the cervix and sigmoid colon accounted for the other two patients. No deaths occurred during hibernation; four patients died between twenty-four hours and three weeks after hibernation. Two patients are still living seven and eight months, respectively, after hibernation. They were entirely free from pain for three months and at present no narcotics are necessary to relieve their discomfort. Roentgenographic studies reveal that the metastatic bone lesions are gradually progressing. High voltage roentgen therapy had been given to all patients before hibernation. Necropsy was performed on two of the four who died; cerebral edema accounted for one death, but nothing tangible could be found to account for the second. Pneumonia was not a cause of death in any case.

Effect of Irradiated Milks on Storage of Nitrogen and Acid-Base Minerals in Children. Frances Cope Hummel and Helen A. Hunscher.

Am. J. Dis. Child. **58**:753 (Oct.) 1939.

To one realizing the difficulties encountered in the biologic assay of food products for their vitamin D potency and the obscurity of the term "vitamin D units," the results of this investigation of the effect of irradiated contrasted with that of nonirradiated milk (judged by the average daily storage of nitrogen and acid-base minerals of well prepared and nutritionally stable children) come as no surprise. The fact that soft tissues may be growing more rapidly at one time and bone at another indicates the necessity of making different types of comparison of the metabolic data and not depending solely on the data concerning retention. From the standpoint of the actual average daily retention alone, it does not appear that the additional vitamin D in irradiated milk (90 to 96 and 180 to 190 U. S. P. units daily) had any nutritive advantage in the deposition of the minerals. On the other hand, the children showed a more rapid rate of growth in length during the periods when vitamin D was the only factor added. The increase in rate of skeletal growth was, in general, accompanied by a higher calcium phosphorus ratio in the retention. This indicates a stimulus to formation of bone and, by the decrease in retention of nitrogen, phosphorus and sulfur, a shift from the formation of soft tissue to that of skeletal structure. Moreover, the variations which occurred in the average daily storage of calcium during the five day balance periods were reduced, which shows a

regulating effect of the vitamin D during the administration of irradiated milk. In addition, all children were storing base in excess of acid while ingesting additional vitamin D, whereas several were actually storing more acid while taking nonirradiated milk, which again shows the development of skeletal structures. It seems justifiable to conclude that vitamin D supplements in the form of irradiated milk included in a dietary known to be nutritionally good and given to children who have good health and good nutritive histories not only exert a regulating influence on the growth impulses but stimulate skeletal development.

Discogenetic Disease. Albert Oppenheimer.

Am. J. Surg. 40:648 (March) 1940.

According to Oppenheimer, the pathogenesis is as follows: Thinning of the discs induces, first, abnormal mobility of the adjacent vertebral bodies, thus causing abnormal stress upon the ligaments that connect them; secondly, abnormal contact between adjacent vertebral surfaces; finally, abnormal position of the articular processes. The stressed ligaments may calcify; contact between vertebral bodies may produce condensation and exostoses; in the displaced facets of the intervertebral (apophyseal) articulations, osteoarthritis may develop; and the diminution of the distance between adjacent vertebrae, together with the displacement of articular processes, may considerably narrow the intervertebral foramina, thus causing pressure upon the nerves that pass through them. Thinning of the discs may be due either to trauma, or to a complex degenerative process, or both; irrespective of its origin, however, it is this thinning which underlies all the changes above mentioned — these changes taking place in vertebral structures that are not primarily diseases. On the other hand, infection or new growth in the vertebrae may secondarily involve the discs; but the mechanical alterations act then upon diseased areas, e. g., softened bone; the results, differing entirely from those observed in normal vertebrae, do not form part of this discussion.

Treatment consists in the prevention of any injury to the spine. Avoiding sudden movements, wearing rubber soles and heels, supporting the neck at night by the addition of pillows, are often very helpful measures. In acute exacerbations, ultrashort wave therapy is the most effective treatment known at present. In radicular neuritis associated with trophic disorders of the skin, muscles or bones, one is impressed with the rapid recovery under this treatment of tissues that seemed to be very seriously damaged. In other less dramatic cases a second recurrence often fails to respond to this treatment as favorably as the first.

Irritation rather than relief may be caused by too frequent or too strong short wave applications. Three treatments a week, of fifteen minutes each, given during a fortnight are usually sufficient. The patient should not experience any sensation during the treatment.

We have now given up manipulations and massage, since they often tend to increase pain. Exceptionally, when short wave treatment is not successful, Roentgen therapy over the diseased area may prove to be helpful.

Pathologic Changes Observed in Human Tissues Subjected to Subcritical Temperatures. Lawrence W. Smith.

Arch. Path. 30:424 (July) 1940.

A series of some 60 patients with cancer, subjected to local or general reductions of temperature and in whom autopsies were made, is presented. The studies are divided into three major groups: (1) normal body tissues; (2) tumor tissue subjected locally to temperatures of 40 to 50 F. for varying periods of time, and (3) metastatic tumor tissue in patients whose general temperature had been reduced to subcritical levels between 74 and 90 F.

In the first group of non-neoplastic, or "normal" tissues, significant changes are the exception rather than the rule. Bronchopneumonia other than the terminal event commonly encountered in cases of advanced malignant disease appeared chiefly in the postrefrigeration period, in association with metastatic involvement of the lungs. Its occurrence with and relationship to refrigeration, accordingly, is particularly difficult to evaluate.

In the second group, temperatures of 40 to 50 F. applied locally to tumors regularly produced regressive changes going on to actual necrosis, even to the point of histologic clearance of the tissue of tumor cells in occasional instances.

In the third group, the changes which were observed in metastatic tumor tissue from patients who were submitted to general reductions of temperature to 74 to 90 F. were similar in kind, but varied greatly in degree in comparison with those resulting from application of the lower temperatures locally. In no instance were regressive changes encountered until ninety-six to one hundred and twenty hours of refrigeration had been given, and in some cases no significant change seemed to occur after three hundred hours of such low temperatures.

On Effect of Light Upon Incidence of Tumors in Painted Mice. I. Doniach, and J. C. Mottram.

Am. J. Cancer 39:234 (June) 1940.

In view of the untoward publicity received by those who in recent years sponsored the theory (or conviction) that sunlight therapy had an influence on the stimulation of skin cancer, the following report is of interest. It points out that light is not essential for the production of tumors of the skin in mice by benzypyrene and cholanthrene. The effect of darkness upon the skin of mice painted by benzpyrene is to reduce dermatitis to a minimum. There is no inhibition of tumor production or of increased hair growth.

The effect of strong sunlight upon the skin of mice coincidently painted by benzyprene is to increase dermatitis and to reduce tumor production. The inhibiting effect of strong sunlight upon the production of tumors of the skin in mice by benzyprene may be associated with the photodynamic (light-sensitizing) property of the hydrocarbon. Dark colored benzyprene manufactured without any precautions to prevent photooxidation appears to be slightly more carcinogenic to the skin of mice than pale benzyprene purified in the dark.

Skin and Bone Temperatures of Schizophrenic and Normal Subjects Under Varying Environmental Conditions. H. Freeman.

Arch. Neurol. & Psychiat. **42**:724 (Oct.) 1939.

Schizophrenic and normal subjects were exposed to varying environmental conditions, in the nude and under fasting conditions. Skin and rectal temperatures were measured by means of thermocouples. It was found that immediately after exposure the schizophrenic patients tended to have warmer extremities than the normal subjects. Exposure to cold conditions [15, 20 and 24 C. (59, 68 and 75.2 F.)], resulted consistently in greater cooling of the skin in the patients than in the normal controls. Exposure to hot conditions [44 C. (110.2 F.)], resulted in no difference in the response of normal and of schizophrenic subjects. Exposure to high humidity at low and high temperatures showed no difference between the patients and the normal subjects. The rectal temperatures of schizophrenic and normal subjects reacted similarly under all conditions. The implication drawn from these studies is that schizophrenic subjects exposed to cold conditions suggests a dysfunction of the neural mechanisms controlling vasoconstrictor tone. Vasodilatation to schizophrenic subjects may be normal.

Ocular Manifestations in Hydroa Vacciniforme. William H. Stokes.

Arch. Ophth. **23**:1131 (June) 1940.

Hydroa vacciniforme is a disease which should be of interest to the student of genetics, to the biochemist and to the clinician as an example of a constitutional peculiarity which renders the patient susceptible to external influences that are harmless to average persons — in this instance a disease provoked by exposure to sunlight. A review is made of previously reported ocular complications in cases of hydroa vacciniforme. The corneal complications as seen with the slit lamp and corneal microscope in 2 patients are reported.

Hypertherm Treatment of Cutaneous Diseases. Elmore B. Tauber, and Leon Goldman.

Arch. Dermat. & Syph. **41**:919 (May) 1940.

For the artificial production of fever at the present time two types of machines are commonly employed. Either singly or in combination a hypertherm (a well insulated box with circulating air, heated and moistened) or a short wave apparatus may be used. The authors present experience in four years of work with the hypertherm in cutaneous diseases. Generalized furunculosis and urticaria showed the most encouraging response. In addition, improvement was obtained in 1 case of subacute and chronic dermatomyositis and in 1 case of keratosis blenorrhagica. In the literature are reports of improvement in cases of psoriasis, mycosis fungoides, Duhring's disease and lymphogranuloma venereum. Apparently, extensive and generalized dermatoses are no contraindications to the use of artificial fever therapy. Generalized miliaria crystallina in a Negro during and after artificial fever therapy is described in detail. The discouraging results with fever therapy alone in a few cases of early syphilis are mentioned briefly. A discussion of the various cutaneous reactions occurring during the period of actual treatment is given. From a critical standpoint, it is difficult to evaluate the importance of fever therapy for the diseases of the skin which were treated. Except for occasional brilliant results this form of treatment was of only doubtful usefulness.

The relatively small measure of success with artificial fever therapy does not warrant the routine use of this major form of treatment in chronic resistant dermatoses. If, however, this form of treatment is decided on, careful attention must be paid to all details, and the treatment must be given only by one who is trained in this field. This is more important than the actual apparatus used.

Effect of Exercise on Volume of Blood. Nolan L. Kaltreider, and George R. Meneely.

J. Clin. Investigation **19**:627 (July) 1940.

Determinations of the volume of the blood were made at rest, and variations in this volume were followed during and after varying grades of exercise in normal subjects and in individuals suffering with cardiac disease. Additional observations include measurements of the blood hemoglobin and viscosity, serum proteins, and venous pressure. The results of this investigation led to the following conclusions:

1. In normal individuals during moderate exertion there is a prompt and definite decrease in the plasma volume, accompanied by a corresponding decrease in the blood volume, while the changes in the cell volume are variable though slight. These changes are associated with an increase in the blood hemoglobin and viscosity, the serum proteins and the venous and arterial pressures. Following exercise the plasma volume gradually increases and 25 minutes after exercise the plasma volume, blood hemoglobin, and serum proteins reach the pre-exercise values.

2. During the exhaustive exercise in normal subjects, there is a further decrease in plasma volume accompanied by a moderate increase in the cell volume. Twenty-five minutes after the cessation of exercise the plasma volume is still diminished and the blood hemoglobin and serum proteins are increased.

3. In patients with compensated heart disease, the changes in the blood volume during and fol-

lowing exercise are similar to those of normal subjects.

4. The increase in red blood cells and hemoglobin concentration resulting from exercise is brought about mainly by passage of protein-poor fluid from the vascular system into the interstitial spaces. It is only during severe or exhaustive exercise that new cells are added to the circulating blood.

The Useful Power Output of Short Wave Diathermy Apparatus. E. Mittelmann, and H. J. Holmquest.

Quart. Bull., Northwestern Univ. M. School **14**:172 (Fall Quarter) 1940.

These authors believe that the misleading use of the term "output power," meaning by this magnitude the total available output of a generator, has been and still is responsible for false conclusions as to the heating effectiveness of short wave diathermy generators. Various measurements indicate that the wattage used in clinical practice is relatively small in comparison with the output power. The maximum power absorption which can be tolerated by a patient during a continuous local treatment is about 100 to 120 watts applied to large parts of the body. Effective fever therapy can be administered with generators having no more than about 200 watts total output power but having a high thermal effectiveness. The thermal effectiveness, or ratio of patient power to total available power, depends on the construction of the generator and the technic of application. In other words, the construction of a generator and the technic of application will determine whether a smaller or larger total power is necessary to obtain the same amount of power absorption in a patient.

The so-called output power of short wave diathermy generators is usually measured by lamp loads under optimal conditions. Such wattage determinations give no indication of the useful power, which is the power absorbed by the patient, because the conditions under which such measurements are made are entirely different from the actual electrical conditions which obtain during the treatment of a patient.

The total power delivered by a short wave diathermy generator is divided into two components, namely, the patient's power and the radiation losses. Both are subject to wide variation according to the technic of application, electrodes, air space, number of turns in the case of the induction cable, and the current flow and its frequency of oscillation. A determination of the amount of the absorbed energy is possible only if components of the total power output are separated. Measurement of the actual power absorbed by a patient is possible by means of a direct reading high frequency wattmeter.

Evaluation of Hyperpyrexia in General Medicine — Davison, Lowance and Crowe

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